BENEATH THE BOTTOM LINE: AGRICULTURAL APPROACHES TO REDUCE AGRICHEMICAL CONTAMINATION OF GROUNDWATER

Volume II--Contract Papers

Part A: The Federal Role

1. Federal Agencies and the Pursuit of Groundwater Protection -- Terry L. Nipp

2. The Federal Role in Reducing Agrichemical Contamination of Groundwater: Appendices A-I -- Laura A. Dye

These contractor documents were prepared for the Office of Technology Assessment (OTA) assessment entitled Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater, OTA-F-418 (Washington DC: U.S. Government Printing Office, November 1990). They are being made available because they contain useful information beyond that used in the OTA report. However, they are not endorsed by OTA, nor have they been reviewed by the Technology Assessment Board. References to them should cite the contractor, not OTA, as the author. Suggested reference style is shown on the title page of each contractor document.

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FEDERAL AGENCIES AND THE PURSUIT OF GROUNDWATER PROTECTION

by

Terry L. Nipp

February 1990

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APPROACHES TO REDUCE AGRICULTURAL CONTAMINATION OF GROUNDWATER:

EVALUATING THE FEDERAL INSTITUTIONAL INFRASTRUCTURE

By Terry L. Nipp, Ph.D.

> *The art of progress is to preserve order amid change, and to preserve change amid order. Life refuses to be embalmed alive.*
> -- Alfred North Whitehead

I. INTRODUCTION

A. FEDERAL AGENCIES, GROUNDWATER PROTECTION AND AGRICHEMICAL CONTAMINATION

Protection of our Nation's groundwater resources has become an issue of pressing concern to the public, to Congress and to many Federal, State and local agencies. Federal agencies are developing and implementing programs to protect groundwater from contamination by agricultural chemicals. However, in the midst of many meetings and the development of endless agendas, are appropriate actions being taken? Out of the endless number of things that could be done, are the most important things getting done first? Who is deciding what the *right and important things* are? Of the things that are being done, are they being done by the *right people*? How much *re-inventing of the wheel* is going on out there?

How much effort is duplicated? How many critical issues are falling through the administrative cracks? In short, does the Federal government have a comprehensive, coordinated, well-planned, and well-developed interagency campaign to protect our Nation's groundwater? If not, why not? If not, what is missing? If not, what can be done to develop such a campaign?

To consider the adequacy of groundwater protection activities of the Federal agencies, there must first be a set of assumptions about the role of the Federal government in affecting the use of agricultural chemicals. For this paper, the *working model* is that public concerns stimulate action by Congress (Figure 1), which legislates directives to the Federal agencies. The Federal agencies interact with each other and with State and local governments to develop programs. These programs in turn are a part of the total mix of economic, social and personal factors which influence the decisions made by individual farmers. The real world is of course more complex, with competing philosophies and mandates. This model does not show all of interactions or feedback that occurs between the agencies, Congress and the public, but Figure 1 does identify the place of the federal agencies in the *grand scheme of things*.

To determine the degree to which particular agricultural practices are contributing to the contamination of groundwater, and to develop alternative practices, it will be necessary to harness and direct the resources of the agricultural research and technology transfer system. The major components of this system are outlined in Figure 2. The organizations that are involved in soil fertility and conservation are shown in Figure 3; these organization will also be involved in addressing water quality issues. A first glance at Figures 2 and 3 may be alarming. The diagrams may appear unnecessarily complex and confusing. Unfortunately, these are fairly simplified schematics that merely identify the organizations that can and probably will be involved in developing groundwater protection policies and programs. These diagrams do not include environmental or related public interest groups. They do not show the breakdown of programs within the identified organizations. They do not show the myriad official and unofficial communication linkages between these organizations. One of the key problems in developing groundwater protection programs should be immediately apparent: a vast array of organizations will have a role in planning and developing such policy and programs.

The scope of this paper will be limited to an examination of the federal agencies, diagramed in the upper right hand corner of Figures 2 and 3. This examination will include a brief study of the agencys' respective organizational structures and the implications of these structures for the development of groundwater protection programs. Some possible options that Congress may wish to consider for facilitating Federal agency activities will be suggested. Finally, a system for integrating and coordinating the activities of the respective agencies will be proposed.

Several studies have reviewed Federal agency activities to protect groundwater. A report by the Congressional Research Service (CRS) is entitled Groundwater Quality: Current Federal Programs and Recent Congressional Activities (Zinn and Tieman, 1989). A study was completed by the Interagency Task Force on Groundwater for the Office of Management and Budget (OMB): A Description on Major Federal Scientific and Technical Ground-Water Programs: Fiscal Year 1987. An assessment also was conducted by the Subcommittee on Ground Water, Committee on Earth Sciences, of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), of the Office of Science and Technology Policy: Federal Ground-Water Science and Technology Programs: The Role of Science and Technology in the Management of the Nation's Ground-Water Resources. The OMB and FCCSET reports focused largely on how much money was being spent in each of the agencies to address specific water quality topics. The OMB report identified the following topical areas, which are fairly similar to the topics identified in the FCCSET report:

- Basic and applied research
  - Fate and transport: organic chemicals
  - Fate and transport: inorganic chemicals
  - Hydrology and hydraulics

- Resource assessments
  - Ground-water quality assessments
  - Ground-water quantity assessments

- Information management and dissemination

- Development, evaluation, and demonstration of technologies
  - Control technologies
  - Monitoring technologies
  - Restoration technologies

- Technical assistance, training and education
  - Training and education
  - Technical assistance to the private sector
  - Technical assistance to State and local governments

- Interagency and intergovernmental coordination

The CRS study focused more on the authorities and responsibilities of the respective programs. Within these reports the following Federal agencies were collectively identified as having activities and responsibilities pertinent to groundwater protection:

- Environmental Protection Agency (USEPA)
- Federal Emergency Management Agency (FEMA)
- National Aeronautical and Space Administration (NASA)
- National Science Foundation (NSF)
- Nuclear Regulatory Commission (NRC)
- US Department of Agriculture (USDA)
  - Agricultural Research Service (ARS)
  - Cooperative State Research Service (CSRS)
  - Extension Service (ES)
  - National Agricultural Library (NAL)
  - Soil Conservation Service (SCS)
- US Department of Commerce (USDOC)
  - National Oceanic and Atmospheric Administration (NOAA)

- US Department of Defense (USDOD)
  - Department of the Army, Corps of Engineers (COE)
  - Department of the Navy
  - Department of the Airforce
- US Department of Energy (USDOE)
  - Office of Energy Research (OER)
- US Department of Interior (USDOI)
  - US Geological Survey (USGS)
  - Bureau of Indian Affairs (BIA)
  - Bureau of Land Management (BLM)
  - Bureau of Mines (BOM)
  - Bureau of Reclamation (BOR)

These studies did not include the Department of Health and Human Services, which would include the Food and Drug Administration and its resident expertise on toxicology. These studies also did not include the Tennessee Valley Authority, which has technical expertise on nutrient management at the National Center for Fertilizer Development.

While all of the cited agencies have pertinent expertise and resources, this study will be limited to an examination of USEPA, TVA, USDA, USGS (Figure 4). Organization charts of each of the agencies are shown in Figure 5, 6, 7 and 8. These charts show only those offices within the agencies that have current or planned groundwater protection activities. Again, critical programs that affect groundwater protection are underway in other agencies, but the selected agencies are currently making the largest efforts to address agricultural sources of groundwater contamination, the subject of this paper:

> Two Federal agencies and one Department have the most important responsibilities for groundwater: the U.S. Environmental Protection

> Agency, the U.S. Geological Survey in the Department of the Interior, and the U.S. Department of Agriculture. If these responsibilities include prevention, detection, and correction, EPA has major responsibilities in all three. USGS is primarily active in detection and the several agencies of USDA mainly address prevention and detection. The Department of Agriculture is limited to agricultural topics, while the other two have broader mandates (Zinn and Tieman, 1989).

There are many documents that describe the activities of the four agencies, a number of which are listed in the Literature section of this paper. The difficulty here will be to summarize the agencies' activities so that the volume of information is not overwhelming, while providing enough information so a real perspective of ongoing efforts can be obtained. To strike such an elusive balance, while avoiding a repetition of work that has already been done, a compilation of excerpts that describe agency programs and authorities is provided. Additional descriptions of agency programs are included in Appendix 2. In addition to these resources, explanations of the groundwater protection programs underway at these agencies can be found in the cited CRS, FCCSET and OMB reports.

As a cautionary note, there is currently a *Schrodinger Effect* that is evidenced when one examines agency groundwater programs. Programs are changing and developing so quickly that the mere act of asking questions or examining the programs may cause changes. The descriptions here may no longer be complete or fully accurate even a few months from the time of this writing.

1. ENVIRONMENTAL PROTECTION AGENCY

- The Environmental Protection Agency has principal regulatory and protection authority for groundwater resources within the Federal Government. Responsibilities for groundwater-related provisions of Federal statutes are dispersed throughout the Agency under the administration of several media-specific offices...The number of offices involved in groundwater activities reflects the fact that EPA is charged with administering several Federal environmental protection statutes that directly or indirectly influence groundwater quality (Zinn and Tieman, 1989).

- The EPA has expressed concern about risk to health and the environment, and with research on sources, prevention, detection, remediation, and migration of ground-water contamination (FCCSET, 1989).

EPA is unique among the four agencies in that all of its programs are specifically mandated by law. It does not have the sort of broad organic authority available to the other agencies[*]. Accordingly, USEPA programs evolve around specific legislative mandates, which are summarized from Zinn and Tieman (1989) below. Comments are made about those provisions of the laws that are specifically pertinent to groundwater protection. The fuller purposes and implications of these laws are not addressed. Because legislation tends to focus on specific media, such as air or water, USEPA and its programs are organized to address these specific media, rather than to track pollutants as they move from one medium to another.

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[*] Several Bills are currently before Congress to establish a cabinet-level Department of Environmental Protection and provide it with organic authority.

EPA Legislative Authorities

o Safe Drinking Water Act (SDWA) (P.L. 93-523)

The Safe Drinking Water Act contains four provisions that specifically pertain to groundwater protection. The SDWA was enhanced by amendments passed in 1986 (P.L. 99-339). The SDWA directs USEPA to --

- set National drinking water standards for allowable levels of contaminants in public drinking water supplies; the 1986 amendments require that 83 standards be set for specified contaminants by June, 1989 -- 9 by June 1987, 40 by June 1988, and the remaining 34 by June, 1989;[**]
- establish regulations for the underground injection of liquid wastes into wells;
- withhold Federal funds to projects (e.g., highways, wastewater treatment plants, and housing) that may contaminate an aquifer that has been designated a sole source of drinking water; and
- provide Federal grants for elective State wellhead protection and sole source aquifer protection programs.

o Clean Water Act (CWA) (P.L. 92-500)

The CWA has several provisions germane to groundwater protection. It grants States the discretion to regulate groundwater under the State water quality standards provision established in the Act. The CWA was last amended in 1987. The following sections of the CWA direct USEPA to take specific actions appertaining to groundwater protection --

---

[**] USEPA is very behind in meeting these deadlines.

- section 106: Water quality management funds are established which can be used to support development of State groundwater management strategies;

- section 208: Requires States to plan for raw sewage waste management to protect both ground and surface water;

- section 303: Authorizes EPA to require States to set groundwater quality standards where there is a clear relation between ground and surface water;

- section 319: Requires States to manage nonpaying sources of pollution and includes a 50% grant program to carry out State groundwater protection activities;

- section 402: Controls industrial and municipal point-source discharges into water, including groundwater; and

- section 520: Authorizes EPA to conduct studies on seven aquifer systems.

o **Resource Conservation and Recovery Act (RCRA) (P.L. 94-590)**

RCRA establishes a strong Federal role in regulating hazardous wastes with a major emphasis on preventing contamination of underground sources of drinking water. RCRA was strengthened by the Hazardous and Solid Waste Amendments of 1984 (P.L. 98-616). According to the report Protecting the Nation's Groundwater From Contamination (OTA, 1984), 22 out of the 33 identified groundwater-contamination sources fall into the waste generation and management category. Subtitles of RCRA with particular affiliation to groundwater protection include --

- subtitle C: Requires *cradle to grave* monitoring of hazardous wastes and creates performance and construction standards, as well as monitoring and reporting requirements for all facilities which store or dispose hazardous wastes.

- subtitle D: Regulates municipal solid waste disposal facilities; the States are responsible for managing the facilities according to EPA-approved plans.

- subtitle I: Regulates underground storage tanks containing petroleum and chemical substances and establishes the leaking underground storage tank trust fund to support cleanup of leaks from these tanks.

o **Comprehensive Environmental Response, Compensation, and Liability Act ("Superfund") (P.L. 96-510)**

"Superfund" gives the Federal Government the authority to respond to discharges of hazardous substances and to clean up contaminated and abandoned hazardous waste sites. A principal purpose of "Superfund" is to prevent toxic substances at hazardous waste sites from leaching into groundwater. The goal is to protect human health and the environment. Section 101(8) defines "environment" specifically to include groundwater and drinking water supplies.

o **Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (P.L. 92-516)**

FIFRA authorizes USEPA to control the use or prohibit sale of pesticides that pose "unreasonable adverse effects on the environment." USEPA is requiring registrants to submit data on the leaching potential of pesticides and to set restrictions on their use as warranted. FIFRA was last amended in 1988.

o **Toxic Substances Control Act (TSCA) (P.L. 94-469)**

TSCA establishes as a national policy that chemical manufacturers and processors are responsible for developing adequate data on the environment and health effects of chemical products. The Act authorizes USEPA to regulate chemicals posing unreasonable health risks, including consideration of environmental, economic, and social costs. Disposal problems are addressed. However, TSCA does not cover pesticides.

EPA Groundwater Protection Initiatives

In response to its diverse groundwater protection responsibilities, the USEPA has devised a "Groundwater Protection Strategy" (USEPA, 1984). In the USEPA plan, the States retain primary responsibilities and authorities to protect groundwater. The plan has essentially four objectives:

1. Support State program development and institution building.
2. Assess potential problems from unaddressed sources.
3. Issue guidelines for consistent Agency decisions affecting groundwater.
4. Strengthen USEPA's organization for groundwater management and cooperation with other Federal and State programs.

Agricultural Chemicals in Groundwater Strategy

In February, 1988, USEPA released its comprehensive plan to improve and direct Federal, State, and local efforts to protect groundwater from contamination. This plan centers around the development of pesticide/groundwater plans by the States. These plans were developed in accordance with section 319 of the Clean Water Act. The Pesticide Office drafted guidelines for the States to follow in the development of their respective plans.

National Water Well Survey

This survey is well underway and scheduled to be completed in 1990. The project involves sampling water from 1,500 wells to test for the presence of 52 pesticides believed to have the greatest potential to leach into groundwater. The survey has two primary goals. First, the study should provide a statistically representative description of the frequency and concentration of pesticide contaminants in the Nation's drinking water wells. Second, the study should assist in developing a better understanding of how pesticide contamination is associated with patterns of agricultural chemical use.

Office Programs

Among the many pertinent offices at USEPA, several require some direct mention, if only because of their names. The Office of Drinking Water (ODW) supports research to establish national drinking water regulations for all public water supplies, including both surface and groundwaters. As mentioned, the 1986 amendments of the SDWA require the development of standards for 83 contaminants. They are currently very far behind schedule.

The Office of Ground-Water Programs (OGWP) was established in 1984. It sustains a relatively small staff that assists States in developing groundwater protection strategies, wellhead protection programs, and sole source aquifer designations (USEPA, 1984). It is also involved in providing technical assistance through workshops and other educational medium. This Office also attempts to coordinate intra-agency policies (USEPA, 1984).

The Office of Research and Development (ORD) directs groundwater research in six major areas: fate and transport, monitoring, aquifer restoration, source control, technical assistance, and health effects (Zinn and Tieman, 1989). ORD is utilized by many of the other offices. Groundwater research is also conducted through private contractors and six EPA laboratories across the country.

After recent chastisement at Congressional hearings regarding the time it is taking USEPA to initiate its programs or develop its programs, new proposals will probably be coming out of USEPA rapidly. USEPA has very recently sent several new ideas for groundwater protection programs over to the Department of Agriculture. They are currently the major underwriter of a project entitled Water Quality 2000. This group is preparing to address the reauthorization of the Clean Water Act in 1992.

2. TENNESSEE VALLEY AUTHORITY

The States that are included in the domain of the Tennessee Valley Authority are Tennessee, Virginia, North Carolina, Georgia, Alabama, Mississippi and Kentucky. TVA has many responsibilities in the region, beyond generation of electrical power. In the area of environmental protection, a 1936 Report to the

Congress stated that --

> The Tennessee Valley Authority law provides that the Authority shall act as a coordinating agency ... to assist in coordinating the efforts of many agencies ... Many problems, such as flood control, navigation, the prevention of stream pollution and the silting of streams, the improvement of domestic and industrial water supplies, and the development of power, are not only inter-related, but are interstate problems, and require some agency to bring about and to facilitate cooperation.

TVA Legislative Authority

The Tennessee Valley Authority Act of 1933 provided broad authority to the agency. The natural resources mission of the agency were defined as follows:

> Sec. 22. To aid further the proper use, conservation, and development of the natural resources of the Tennessee River Drainage Basin and of such adjoining territory as may be related to or materially affected by the development consequences of this Act, and to provide for the general welfare of the citizens of said areas, the President is hereby authorized, by such means or methods as he may deem proper within the limits of appropriations made therefore by Congress, to make such surveys of and general plans for said Tennessee Basin and adjoining territory as may be useful to the Congress and the several States in guiding and controlling the extent, sequence, and nature of development that may be equitably and economically advanced through the expenditures of public funds, or through the guidance or control of public authority, all for the general purpose of fostering an orderly and proper physical, economic, and social development of said areas; and the President is further authorized in making said surveys and plans to cooperate with the States affected thereby, or subdivisions or agencies of such States, or with cooperative other organizations, and to make such studies, experiments, or demonstrations as may be necessary and suitable to that end.

TVA Programs

The Tennessee Valley Authority's operations are divided into two fiscally distinct categories (Runyon, 1989). The power generating programs are self-supporting, funded by revenues from TVA ratepayers. TVA also has "Resource Development" programs, funded out of TVA's appropriated budget. The Resource Development program includes the National Fertilizer Development Center (NFDC) and their Water Resources program within their River Basin Operations. TVA's nonpoint source and groundwater protection programs are largely addressed in the context of the drainage basins and tributary streams within the TVA regional boundaries.

Within its broad authorities, TVA has defined for itself the following water quality responsibilities (TVA, 1988b):

1. To integrate land, water, and use consideration in comprehensively addressing point and nonpoint source pollution problems on a watershed basis, and,
2. To work cooperatively and facilitate local, State, and Federal efforts to control pollution and maintain the quality of surface and groundwater resources in the Tennessee Valley.

Water quality protection activities are included as part of the following budget categories: Regional Water Management, Reservoir Releases Improvements, Reservoir Ecology, the Agricultural Institute, and National Fertilizer Research and Development.

Land and Water 201

There are 201 counties within TVA's seven states. In 1984, a "Memorandum of Understanding" was signed by the various soil and water conservation agencies operating within the seven TVA states to develop cooperatively a "Land and Water 201" program. The involved agencies identified four broad objectives: (1) to reduce soil erosion, (2) to improve water quality, (3) to increase farm income, and (4) to serve as a national model and demonstration for multiagency cooperative soil and water conservation programs (TVA, 1988a). The agencies determined that--

- Of the 104 hydrogeologic units making up the 201-county region, 71 are reported to have threatened of impaired water quality from nonpoint source (NPS) pollution,
- Agricultural land uses are estimated to be predominant sources of pollutants in 70-80 percent of hydrologic units with threatened or impaired waters from NPS in the region,
- Livestock is responsible for a daily manure production equivalent to untreated sewage from 47 million people (seven times the region's population), and
- A high percentage of the region is underlain by hydrogeologic conditions highly vulnerable to groundwater contamination (TVA, 1988a).

Environmental Initiative

TVA significantly reduced its staffing a year ago, in response to declining resources and administrative and Congressional interest in streamlining their operations. During this time, considerable restructuring is underway or being planned. As part of this effort, a task force considered:

- TVA's past work and expertise in areas related to environmental protection,
- NFDC's current research and development activities that have nutrient-related environmental implications, and
- Requests to NFDC from fertilizer industry and other groups for assistance in complying with environmental regulations (TVA/NFDC, 1988).

The Task Force recommended that an Environmental Program be established within NFDC that will have 3 major thrusts: (1) containment and compliance, (2) research and development, (3) information and education (Appendix 2). The research and analytical capabilities housed at NFDC and their working relations with fertilizer dealers will be pertinent to the development of national nutrient management programs.

3. UNITED STATES DEPARTMENT OF AGRICULTURE

- There are nine agencies of the Department involved in research, education, and technical assistance programs. We recognize the impact that agriculture has on groundwater, and we recognize our responsibility to protect this natural resource (Mussman, 1989).

- The USDA has focused on the development of needed scientific knowledge and on the practical problems of agricultural productivity and profitability while preserving ground-water quality and quantity (FCCSET, 1989).

- During the past couple of years, the Department has repeatedly expressed a growing commitment to an enhanced water quality improvement effort, of which groundwater is a major component. The Department and its agencies have released numerous reports and work plans that define how the commitment is to be met. Meeting it will require USDA to maintain a consistently high level of effort for several years or longer. This commitment includes funding agency groundwater programs over competing priorities and providing adequate staff resources (Zinn and Tieman, 1989).

USDA Programs

USDA has broad organic authorities to address all issues that impact on American agriculture. Consequently, programs to protect groundwater from agricultural chemicals have developed within offices that have broader historical mandates and functions. Many offices have programs that can impact groundwater protection, but in the context of their basic functions. For example, the Agricultural Research Service is involved in many research projects, including those germane to groundwater protection. The Extension Service is involved in many education programs, including projects to protect groundwater. The groundwater protection functions of the offices within USDA are detailed in Appendix 2. A number of USDA offices have programs specifically directed towards protecting groundwater quality. Other offices can have profound, though secondary impacts on groundwater protection.

The Office of Budget and Program Analysis (OBPA) has been very involved in the development of intra-agency coordination and the development of integrated budgets and plans. OBPA is not involved in program administration, but works with the program Administrators and the Office of Management and Budget.

Within the International Affairs and Commodity Programs, the Agricultural Stabilization and Conservation Service (ASCS) provides for cost-share funding for technical assistance projects. Historically, ASCS funding has been to support programs suggested and managed by the Soil Conservation Programs. ASCS also administers farm support programs, and is involved in making sure that farmers comply with government requirements to get program benefits. There are plans to provide cost-share funding for groundwater protection projects under the Rural Clean Water Program.

> The Farmers Home Administration (FmHA) does not conduct research, technology transfer, public information, nor educational activities related to water quality. FmHA does, however, operate several significant loan and grant programs designed to positively affect the quality, conservation, and use of water on farms and in rural communities (Michael Wilinson, Deputy Administrator, Program Operations, USDA, 1989).

As stated, FmHA does not directly address groundwater quality protection. However, it can have a significant impact through the provision of loans, or through stipulations that groundwater be protected as a condition for project loans. The involvement of FmHA in groundwater protection has not yet been well explored.

The Economics Research Service (ERS) conducted a national study on The Magnitude and Costs of Groundwater Contamination from Agricultural Chemicals: A National Perspective (Nielsen and Lee, 1987). ERS is also developing pesticide use data bases and examining the feasibility of developing computerized maps to analyze the relationships among land use, soil characteristics, and water quality. ERS is working to coordinate with USEPA and USGS in these activities (USDA/ERS, nd).

The National Agricultural Statistics Service (NASS) works with ERS in the development of data management and statistical analyses. NASS has two programs of its own relevant to groundwater protection: the Crop Livestock Estimates Program, relevant to waste management, and the Statistical Research Program.

Within Marketing and Inspection Services, the Animal and Plant Health Inspection Service (APHIS) has programs that are applicable to groundwater protection. These programs affect the amount and ways that agricultural chemicals are used, which in turn impacts on how these chemicals move through the environment and into groundwater.

The Forest Service (USFS) has long been involved in projects to improve land management practices, with particular efforts to protect surface waters from chemical sediment loading. The Forest Service is interested in integrating its watershed and surface water protection programs into efforts to protect groundwater.

The Soil Conservation Service (SCS) has some 50 years of experience in projects to protecting surface waters from sediment loading from erosion. They have developed "Best Management Practices" to reduce soil erosion caused by agricultural production practices. SCS provides technical assistance to farmers in the planning, installation, and maintenance of conservation practices. The Resources Conservation Act of 1977 required SCS to develop a national plan and program for soil and water conservation. The resulting report lists the Department's priorities for soil and water resource protection for the next decade. The most recent update to this plan was completed this year. It includes significant redirection from the last national plan, completed in 1982. In this updated plan, water quality protection moved from the sixth national priority to the second.

The Rural Clean Water Program (RCWP) was established in the late 1970's, as an amendment to the Clean Water Act. The RCWP includes joint efforts by SCS and USEPA to develop demonstration projects to protect water quality. The projects focused on surface water monitoring and protection, but lessons have been learned that are pertinent to watershed management and groundwater protection.

Current SCS activities focus on 3 initiatives: (1) developing groundwater protection components for the SCS Technical Guides; (2) developing a comprehensive system to assess how conservation programs affect both ground and surface water; and (3) training field staff in aspects of groundwater (USDA/SCS, 1987). SCS has signed a "Memorandum of Understanding" with the Extension Service for assistance in the updating of the Field Office Technical Guides. SCS has also signed a "Memorandum of Understanding" with USEPA to assist USEPA in implementing section 319 of the Water Quality Act of 1987. SCS is providing technical assistance to States for development of plans to address nonpoint pollution problems. As well, SCS has detailed an SCS representative to each of the 10 regional USEPA offices. SCS has just announced its plans to develop water protection programs in 37 hydrologic regions that were identified as being at risk in the 319 program.

The Agricultural Research Service (ARS) is engaged in basic and applied research on agricultural concerns. ARS serves as the agricultural "R&D" department for the Federal government. ARS has identified 3 goals in the study of potential groundwater contamination by agricultural chemicals: developing a better understanding of the basic physical process of fate and transport of agricultural chemicals in the environment, developing better management practices for agricultural chemicals, and creating better predictive and diagnostic tools to interpret field observations. In 1988, ARS released its Strategic Groundwater Plans for Nitrates (USDA/ARS, 1988a) and its Strategic Groundwater Plans for Pesticides (USDA/ARS, 1988b). ARS, the Cooperative State Research Service and the State Agricultural Experiment Stations cooperated in developing a USDA Research Plan for Water Quality (USDA/ARS & CSRS, 1989).

The Cooperative State Research Service (CSRS) provides federal funding to State agricultural research programs. Each State has an Agricultural Experiment Station (SAES) and a Land Grant University, which conduct research on agricultural concerns within the States (a description of the laws establishing SAES and the Land Grant Universities is provided in Appendix 2). CSRS is the means through which a partnership between the Federal government and State programs is established. Unlike ARS, which has a *top-down* administrative structure, CSRS is more of a *coordinated confederation*. The strength of CSRS is that it does extensive research in every State and has the dispersed infrastructure and programs necessary to examine farm management practices in local and specific environments. One criticism sometimes directed against CSRS is that its responsiveness to State and local concerns makes it less responsive to Federal and national priorities. However, the Federal government provides less than a third of the funding support for agricultural research programs in most States. Similarly, the State institutions provide most of the personnel dedicated to agricultural research, as shown in Figure 9. A *scientist year*, the measurement used in Figure 9, is a calculation of the amount of time that would be invested by a full-time scientist, including the staff support necessary for the scientist to function. The relative number of scientists from different agencies involved in water quality work parallels the ratios shown in Figure 9.

The State Agricultural Experiment Stations, and the State Cooperative Extension Service cooperate with their Federal partners, including in the development of national water quality protection programs. However, these institutions are not part of the Federal government. They have organized to coordinate their respective interests through the National Association of State Universities and Land-Grant Colleges (NASULGC). This membership of this association is comprised of 149 major U.S. public research universities, including all U.S. Land Grant institutions. Within NASULGC, the Experiment Station Committee on Organization and Policy (ESCOP) serves as the representative governing body of the State Agricultural Experiment Stations and the Extension Committee on Organization and Policy (ECOP) serves as the governing body representing the State Cooperative Extension Services.

ESCOP and ECOP have been working cooperatively for a number of years to develop an awareness of the need to protect our nations's groundwater. In 1985, they jointly published a report entitled Groundwater Quality and

Management: Research and Extension, which states:

> Few doubt that contamination of groundwater is a growing problem. The impact of agricultural quality and quantity is an issue of major national importance. Proper management of agricultural systems to maintain acceptable groundwater quality is increasing in importance. Research efforts need to be focused on physical, chemical and biological processes that influence groundwater quality...There is an immediate need for increased research on source and prevention, fate, remedial, impact and institutional issues.
>
> ...Technology transfer through Cooperative Extension is proposed to transmit benefits of research investment to the public. Issues of training and numbers of personnel are key constraints to Extension's programming in groundwater quality.

A preliminary study was done to determine the amount of money and personnel being devoted to water quality at the State Agricultural Experiment Stations (Appendix 2). As the first step in the study, a search for water quality projects was conducted on the computerized Current Research Information System (CRIS), which is housed at the National Agricultural Library (Nipp, 1989, Volk, 1989). Because there is no category that explicitly identifies research projects relevant to water quality protection, potentially relevant projects were identified using a *word search* that located projects with water quality related terms in their descriptions. Each identified project was then individually reviewed and assigned, if appropriate, to one of ten classification categories:

Surface Water

1. Pesticides, organic compounds, and heavy metals;
2. Nutrient and waste materials;
3. Water management;

Groundwater

4. Pesticides, organic compounds, and metals.
5. Nutrients and wastes.
6. Recharge, irrigation, and precipitation.

General

7. Soil and crop management.
8. Impact on biological systems.
9. Geologic background.

Relevant but Indirect

10.Indirect water quality research.

Many projects were relevant to several categories and personal judgement had to be utilized to determine what percent of the total project effort would be assigned to individual categories. The last category of "Relevant but Indirect" was not included in the calculations of dollars and personnel assigned to water quality protection.

Aggregating for the nation, it was determined that for fiscal year 1987, $16.3 million dollars were spent through the Cooperative State Research Service. These funds were allocated over some 818 projects that included water quality components. State and other non-federal funds amounted to $85.7 million, allocated over some 4,305 projects. Collectively, the States and local entities are spending more than 5 times the amount invested by Federal government. Studies of fiscal years 1988 and 1989 are still underway.

New allocations for university research on the relations of agricultural production to water quality protection became available in the FY 1989 budget: of the $3 million appropriated for water quality money through the Cooperative State Research Service, approximately $1.2 million was directed funding, leaving approximately $1.8 million nationally for new research projects. The money was divided evenly between the four research regions of the country: northeast, north central, south, and west. Leading scientists within each region met to identify and prioritize water quality research issues within their regions. Some 238 research proposals were submitted, of which 23 were funded (Nipp, 1989, Volk, 1989). Descriptions of the projects that received funding are included in the attachments. Over a hundred of the proposed studies were of sufficient quality to have received funding, had funds been available.

The Extension Service is USDA's education and outreach arm. It was developed to transit new technologies and information to farmers and ranchers. Like CSRS, the Extension Service involves a partnership between Federal and State governments. The Cooperative Extension System also includes very strong involvement of local governments. Each of the three government partners contribute to the financing of Extension operations, however, in many States the State and local governments contribute much more than two-thirds of the funding. As a *coordinated confederation*, the Extension Service can respond well to local issues and concerns, but it has been criticized by some for not responding more directly to national priorities and concerns.

In response to this concern, the Federal Extension Service has worked to develop nine focused priority issue areas, which includes water quality protection. However, States and local counties elect whether or not they wish to participate in these programs. In fiscal year 1989 approximately $1.5 million in new appropriations were made available to address water quality concerns through the Extension Service, which identified three high priority issues for the FY 1989 program:

(1) the interactions of pesticides, soils, and water quality;
(2) the interactions of nitrogen fertilizers, soils, and water quality; and
(3) the testing and treatment of rural water supplies.

Each State was invited to submit proposals to address these issues; each projects could cost up to $25,000 per State, but the Federal funds had to be matched by funds from the counties or State.

A large body of educational materials on water quality protection have been developed by the Extension Service. Some samples of some of these materials are included in Appendix 2.

The National Agricultural Library (NAL) serves as the national repository of references on agricultural issues and concerns. Task groups have been set up to answer and direct questions in areas of social concern, including a task force on alternative agricultural products. The NAL compiled an extensive bibliographic search on articles pertinent to groundwater protection, funded by USEPA. A computer bulletin board has been established at the Library, which includes the *Water Information Network*. The NAL also manages the Current Research Information System (CRIS). While there is interest at NAL in addressing groundwater protection issues, scarce resources have prevented a more direct involvement.

Water Quality Initiative

In 1987, the Office of Management and Budget (OMB) initiated the Interagency Task Force on Groundwater, to develop the previously mentioned study of agency programs to protect groundwater quality. OMB has since worked with Federal agencies to develop a coordinated intra-agency groundwater protection strategy. These efforts culminated in the President's Water Quality Initiative (WQI) for fiscal year 1990. In the WQI, USEPA, USDA and USGS have identified as having primary responsibilities for groundwater protection. However, in the President's budget proposal, most of the proposed funding increases of over $40 million dollars is directed to USDA.

Back in 1987, an intra-agency task force on groundwater was created with representatives from 22 USDA offices. This task force developed a general policy statement regarding USDA's interests and responsibilities in groundwater protection. This statement was approved by the Secretary of Agriculture in November of 1987 (USDA, 1987). The task force also began developing groundwater protection program plans. In 1988, an interagency working group developed the working plans for a Departmental response to OMB's request for a Department-wide initiative. Since then, numerous committee meetings have resulted in the development of the Water Quality Program Plan to Support the President's Water Quality Initiative (USDA, 1989e). Currently, efforts are underway to complete a draft of a plan to incorporate the activities of USDA, USEPA, USGS, and NOAA.

The Water Quality Program Plan to Support the President's Water Quality Initiative (USDA, 1989e) states that:

> - The USDA Water Quality Program will be carried out through three major, integrated and interdependent functional components: (1) Education and Technical Assistance, (2) Research and Development, and (3) Database Development and Evaluation.
>
> - Education and technical assistance efforts will assist farmers, ranchers and foresters in applying new and improved agrichemical and waste management and agricultural production practices based on already available research results and new techniques, practices and systems developed through the research and development program component. The adoption of practices to reduce or prevent contamination will be encouraged and accelerated where existing or potential contamination of ground or surface waters from agricultural nonpoint sources has been identified as a public concern...

- Research and development efforts will provide new and improved agricultural and forestry management practices and systems that will increase farmer, rancher and forester effectiveness in reducing the chances of water quality degradation for a wide range of conditions. Research is essential to expand and improve our understanding of the mechanisms that govern the movement of agrichemicals through soil and geologic materials and that govern how much chemicals become available in forms that readily move through these media into groundwater...

- Development of comprehensive, consistent, periodic national data on agricultural chemical use, related farm practices, and links with the physical environment will provide the necessary basis for Federal agencies and State government to assess the implications of current agricultural practices and to evaluate the consequences of alternative policies for reducing any adverse effects of agricultural production on water quality. Centralized systems for linking data and statistical information on agricultural productivity, land use, agricultural chemical use, physical attributes of the land and surrounding watersheds, climate, and water quality will support a variety of program decisions by a range of Federal and State agencies, including those requiring improved pesticide benefit assessment.

As a result of these efforts, the following "Output and Program Support Activities" were identified.

- Building National and State databases on agrichemical use and related farm practices

- Providing digitized geographic information systems for State and Federal evaluation of alternative policies and program strategies

- Developing methods for sampling, measuring, and evaluating groundwater contamination

- Conducting fundamental research to provide the basis for improved management of chemicals in agriculture

- Improving agrichemical management and agricultural production systems
- Expanding USDA and CES staff capacity to deliver educational and technical assistance to producers for effective agrichemical and waste product management and environmental stewardship
- Demonstrating and delivering technologies and management systems for voluntary farmer, rancher and forester adoption and implementation
- Meeting State water quality requirements through education and technical assistance
- Evaluating economic, social and technical effects and impacts of new and improved management practices and systems
- Informing the public of program activities and achievements.

It is argued that these efforts will make up a fully integrated system, with outputs that rely upon successful completion of related program efforts. Meanwhile, the Department of Agriculture has been examining ways to coordinate the many planning and program efforts that are underway. One option being considered is the creation of a coordinating committee to address environmental issues at large, that will report directly to the Deputy Secretary. Water quality coordination would be addressed within this committee. An announcement regarding the Departments plans should be released any day, quite probably before the release of this document.

4. United States Geological Survey

- The United State Geological Survey of the Department of the

> Interior has primary responsibility for assessing the quantity and quality of the Nation's water resources and providing hydrologic information. Both the assessment and information exchange activities performed by the Survey provide essential support to many of the groundwater protection programs of State, local and Federal agencies ... Although a number of Federal agencies and Departments undertake groundwater research and information activities, the USGS is assigned the task of coordinating and disseminating Federal information (Zinn and Tieman, 1989).

- ...These and many other data collection, investigation, and research efforts result in a single product -- information. The Geological Survey has no resource management, development, conservation or regulatory functions. We do not advocate policy positions on resource management. Our role is to provide scientific facts and understanding that are needed to make more effective decisions...Geologic Survey information takes many forms - maps, reports, books, computer data bases, and photographs (Lopez, 1988).

- The DOI(USGS) has taken a longer-range view of the problem as one of improving the scientific knowledge base to allow informed analysis of alternatives for decision-making (FCCSET, 1989).

USGS provides data and information through 76 centers nationwide. Much of its efforts are dedicated to monitoring and detection of contaminants at a number of sites. As well, it maintains a large scientific program to study movement and fate of chemicals in the environment. In fiscal year 1987, USGS spent about $110 million on research pertinent to groundwater protection, about one-half of the amount spent by Federal agencies, according to the Interagency Task Force (OMB, 1988).

USGS is also responsible for coordination and dissemination of Federal information on groundwater. It releases a comprehensive report on water resources each year, the National Water Summary. This document includes comprehensive documentation on water resources in each state and includes case studies of nonpoint source contamination. This Summary also includes studies on managing and coordinating Federal and State water protection efforts. USGS maintains a computerized National Water Storage and Retrieval System (WATSTORE) and a computer based National Water Data Exchange (NAWDEX).

USGS provides information and technical assistance to other agencies seeking to comply with legislated mandates. USGS assists USEPA and other agencies to respond to provisions of the following acts: National Environmental Policy Act, Safe Drinking Water Act, Clean Water Act, Rural Conservation and Recovery Act, Superfund, Energy Security Act, Low-level Radioactive Waste Policy Act of 1980, Nuclear Waste Policy Act of 1982, Federal Land Policy and Management Act of 1976, and Surface Mining Control and Reclamation Act of 1977 (Zinn and Tieman, 1989).

Within USGS, there are three major Divisions -- Mapping, Water Resources and Geology

> ...having a total of about 10,000 employees, of which about 5,000 are in the Water Resources Division (WRD). Of the 4,000 WRD employees, about half are scientists and engineers--mostly geologists and hydrologists. The employees of the WRD are located throughout the States in more than 200 offices...Funding for WRD comes from hundreds of sources. A little more than half of the funding in provided by Congress in the form of appropriations. Almost a fourth

is provided by nearly 1,000 State and local governmental cooperating agencies. The remaining fourth is provided by other Federal agencies in payment for specific technical assistance that the WRD performs on their behalf (Lopez, 1988).

The Geologic Division engages in geologic mapping and research that provides a physical or conceptual basis for evaluating flow pathways of groundwater.

USGS Legislative Authorities

Like USDA, USGS has broad organic authorities to pursue its primary missions. According to document entitled "Office of Management and Budget Circular A-67," written in 1964, USGS is charged with responsibility for interagency and intergovernmental ground and surface water data coordination. USGS is to encourage consistency in data collection and storage and to strive to avoid unnecessary duplication of data collection efforts. To this end, USGS's activities include:

(1) preparing recommended methods for data acquisition and analysis,

(2) maintaining a computerized index of water data, and

(3) preparing annual reports on Federal agency plans for acquisition of water data (OMB, 1988)

In addition to its broad authorities, the Water Resources Research Act (WRRA) authorizes USGS to provide funding to States. Originally, the State-Federal funding ratio was 1 to 1 beginning in 1985 (Zinn and Tieman, 1989). There has since been a decrease in the Federal contribution and the States must now contribute twice the federal investment.

USGS Programs

- National Research Program

USGS is engaged in a broad array of research projects pertinent to groundwater management and protection.

> The water resources research program is organized into six major research disciplines: Water Chemistry, Geochemistry, Ground-Water Hydrology, Surface-Water Hydrology, Geomorphology and Sediment Transport, and Ecology....Decades of research in ground water led to some of the earliest development of mathematical flow models that are capable of describing the response of aquifer systems to a wide range of stresses....Later work on chemical reactions in ground water was coupled with ground-water flow models to begin predicting the movement and fate of ground-water contaminants (Lopez, 1988).

USGS maintains extensive research programs on fate and transport of chemicals in groundwater. As well, USGS maintains a national Groundwater Assessment Program to study basic hydrologic processes that may affect groundwater.

- National Water Quality Assessment (NAWQA) Program

Begun in 1986, the NAWQA program involves national and regional assessments of the status of groundwater resources and monitors trends in the factors than can affect groundwater quality. A number of nonpoint source contamination problems are studied, including agrichemicals, at 7 pilot project areas (Zinn and Tieman, 1989). The full-scale national program would involve

4-50

120 study areas nationwide. USGS is looking for gaps in current data on studied chemicals, and is developing its programs to address these data gaps.

- Regional Aquifer Systems Analysis (RASA) Program

The RASA program gathers data on the quantity of water resources available in the nation's aquifers. The program was initiated in 1978. Twenty-eight aquifer systems were originally identified for study; fourteen of which have been completed (Lopez, 1988). Objectives of the program are to:

1. Determine availability and chemical quality of water stored in each aquifer systems.
2. Determine discharge-recharge characteristics of each aquifer system.
3. Develop computer simulation models for each aquifer to assist in understanding ground-water flow regime and changes brought about by human activities, such as pumping (Lopez, 1988).

- Toxic Substance Hydrology Program

The Toxic Substance Hydrology Program studies how to mitigate waste disposal problems. It is monitoring and evaluating available techniques for studying fate and transport of toxic chemicals through the hydrologic system.

- Federal-State Cooperative Program

USGS supports local efforts to collect data on ground and surface waters by providing cost-share support for State and local governments. USGS has provided support for mapping State aquifers. It has also assisted in developing wellhead protection programs. As well, USGS has supported programs to monitoring the source and extent of pesticide contamination problems.

- State Water Resources Research Institute (WRI) Program

This program provides grants to 54 State and Territory Institutes for research, for information dissemination, and for training students in water resources. About 35% of work conducted through WRI is related to groundwater protection. WRI typically receives about $10-$11 million each year. The WRI's authorizing legislation needs to be renewed in this session of Congress. At this time, the language to reauthorize the Institutes has been incorporated in groundwater protection bills that cover a broader array of interests. Unfortunately for the Institutes, these bills appear to be stalled in the Congressional committees reviewing them.

- Mid-Continent Initiative

Similar to USDA's Midwest Initiative, USGS identified a region of the country for intensified examination.

> The mid-continental United States was selected for study because the region is dominated by cropland devoted to corn and soybean production where pesticide applications are substantial. The combined pesticide use of the States in the region is about 50 percent of the national total (Gianessi, and others, 1986). The region approximately coincides with the Upper Missouri and Ohio River Basins. The coincidence of hydrologic boundaries and land use provides an opportunity to examine differences in water quality as the result of different land use and agricultural practices....Atrazine...was selected as a representative herbicide for this study because it is the

> most widely used triazine herbicide and has the longest history of continuous use (Ragone, et al., 1988).

The overall objective of the study is to improve understanding of processes and factors that affect regional distribution of Atrazine in ground and surface waters. A further description of this study is included in Appendix 2.

5. INTERAGENCY COORDINATION AND PROGRAM PRIORITIZATION

Given the many water quality protection programs that are underway in each agency, it is not surprising that there is wide spread concern that there should be sufficient coordination among the Federal agencies. Historically, the role of interagency coordination on water issues has resided with USGS.

> At the national level the Office of Water Data Coordination [USGS] is responsible for interagency coordination; the work is accomplished primarily through two major committees. One is the Federal Interagency Advisory Committee on Water Data that has representatives of about 30 major organizations including the Environmental Protection Agency and the Department of Agriculture. The other committee is the non-Federal Advisory Committee on Water Data for Public Use. The non-Federal Advisory Committee includes representatives of 16 major water-related advisory organizations...these two committees work to identify water-resources-information requirements, to help plan effective programs for obtaining and sharing needed information, and to document recommended methods for acquiring water data (Lopez, 1988).

However, both OMB and Congress have expressed concerns that more detailed and cooperative planning efforts be established to facilitate coordination both within and among agencies. This has resulted in development of new coordinating mechanisms. In addition to generating the previously cited report on agency activities, the Subcommittee on Groundwater of the Committee of Earth Sciences of FCCSET has been made responsible for

> coordinating Federal nonregulatory ground-water efforts related to research, resource assessment, information management and dissemination, technology demonstration, technical assistance, training, and education. The membership of the subcommittee includes the Departments of Agriculture, Commerce, Defense, Energy, and Interior, the Council on Environmental Quality, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Nuclear Regulatory Commission; and the Office of Management and Budget (FCCSET, 1989).

The subcommittee is empowered to address significant science and information issues of national importance that cut across agency boundaries in order to:

- Review Federal science, information, and technology programs directly related to groundwater.
- Help ensure that these programs are complementary and not unnecessarily duplicative.
- Improve planning, coordination, and communication among Federal agencies involved in ground-water research.
- Identify and define ground-water research, technology, and information needs.
- Address specific programmatic or scientific issues which affect two or more agencies.
- Provide reviews, analysis, advice and recommendations to the Committee on Earth Sciences on Federal policies, and programs concerned with ground-water research and information.

The FCCSET subcommittee has responsibility for supplementing and facilitating implementation of existing "Memoranda of Understanding" (MOU's) and other cooperative agreements that exist among agencies. Description of some of these MOU's and other coordinating committees and activities are provided in Appendix 2A3.

As water quality program staffs interact, they are developing a greater understanding of each others' programs. As well, agency staffs appear to be evolving a deeper understanding of bureaucratic, budget, and political forces that influence behavior of their counterparts. As a result, there is a growing effort to plan and develop new programs jointly. For example, USDA and USGS have merged their Mid-West and Mid-Continent initiatives to study effects of agricultural chemicals on groundwater. As well, in the case of USDA's Water Quality Initiative:

> The planned activities of 8 principal USDA Agencies and the State Agricultural Experiment Stations and Cooperative Extension Services are closely coordinated with each other and with related activities of EPA and Agencies of the Departments of Interior and Commerce under the President's Water Quality Initiative. The USDA Water Quality Program will benefit from related, past and ongoing Departmental efforts in soil and water conservation, public information, research, and extension, and will complement the aims of other targeted programs such as Integrated Pest Management (IPM), Low Input Sustainable Agriculture (LISA) and the National Agricultural Pesticide Impact Assessment Program (NAPIAP) (USDA, 1989e).

Despite these diverse coordinating efforts, Congress and outside groups still express concern over how groundwater protection research priorities are being established within the diverse programs. To paraphrase Representative Jamie Whitten, of the House Appropriations Committee: it doesn't matter if the best work is being done by the best people if the wrong questions are being addressed. The issues and approaches used by Congress, interest groups and research community may be fundamentally different. Congress and interest groups often look for a solution to a specific problem. The research community appears to be more interested in studying mechanisms that are involved in the problem instead of developing comprehensive solutions. These divergent communities often express their frustrations with other group's inabilities to understand what needs to be done. As a preliminary step towards facilitating communication between these groups, and developing a *common language* among them, the Agricultural Research Institute[***] is in the process of developing a workshop to assess the research prioritizing process for groundwater protection (Appendix 4).

B. Some Fundamental Issues for the Federal Agencies

> *We are too much accustomed to attribute to a single cause that which is the product of several, and the majority of our controversies comes from that.*
>
> -- Baron Justus von Liebig (1803-73)

[***] The Agriculture Research Institute is an organization that represents university and private sector scientists engaged in agricultural research.

It would be futile to attempt to chronicle the diverse debates that are underway regarding the actual threat of groundwater contamination by agricultural production. In this paper it is assumed that there are groundwater contamination problems that need addressing and that Congress will be asking Federal agencies to act. However, some issues must be recognized. For example, should voluntary education programs or non-voluntary regulatory programs be developed? The answer to this question should significantly affect which agencies are directed to act and what they are directed to do.

Each agency has a unique history and set of resources for protecting groundwater. USGS has a history of pure science and research; it provides data and data coordination for other agencies. TVA and USDA also engage in basic research, data collection and monitoring, but in addition they are involved in applied research, technology transfer and technical assistance. USEPA is involved in the preceding activities, but also has regulatory and enforcement responsibilities.

The structural characteristics of each agency lend themselves, with greater or less ease, to the resolution of different types of problems. TVA, USDA and USGS have always maintained considerable *in-house* scientific and technical expertise. Comparatively, USEPA contracts out much of it program activities to private organizations and to other agencies. This might provide USEPA with greater institutional flexibility, but it also limits its *institutional memory.* USEPA is also managed through fairly independent offices and regional headquarters. TVA has considerable expertise in nutrient management that has national implications, but until recently, its considerable experience in facilitating interagency coordination has been largely in the Southeast. USGS has the most extensive experience in developing integrated national programs to map and study hydrologic features. USDA has by far the most extensive education, technical assistance, and technology transfer networks, that reach out to almost every county in the country.

USGS and USDA have both centralized *top-down* management programs and decentralized *confederated* programs. Many USGS programs are funded and supported by individual State programs. The USGS Water Resource Institutes operate with near autonomy within each State. Similarly, the Extension Service and Cooperative State Research Service of USDA provide excellent structures for responding to *ground-up* prioritizing at State and local levels. However, because so many diverse issues are addressed within each State, these systems have had to struggle to develop a nationally visible coordinated agendas. On the other hand, the Agricultural Research Service has a *top-down* management structure. The ARS structure facilitates its ability to respond to national goals, but the system lacks the many site-specific research locations that will be necessary to develop individual farm management programs. The potential for a coordinated response to a national agenda that is resident in top-down structures will have to be integrated with local, site-specific capabilities inherent in *bottom-up* organizations.

Fundamental assumptions about the nature of groundwater contamination problems will determine what combination of agency programs will be best to protect groundwater. Several issues are of particular importance: recognizing that natural resource boundaries rarely coincide with political or administrative boundaries, Federal and State government have distinct but potentially overlapping authorities, programs may be mandatory or regulatory, and programs may emphasize remedial and preventive action or continued research and data collection.

1. ADMINISTRATIVE AND POLITICAL BOUNDARIES VERSUS NATURAL RESOURCE BOUNDARIES

Water moves continuously through the environment in a *hydrologic cycle*, shown in Figure 10. Water falls as precipitation from the sky. It runs off the soil surface into streams, lakes and oceans. It infiltrates through the soil surface and moves through the soil profile, percolating through the root and soil zones, through the intermediate or vadose zone and into the saturated zone (Figures 11 and 12). As agricultural chemicals are transported through the soil profile, a number of physical and environmental parameters may influence their fate and transport (Figure 13).

Groundwater is not usually found in large empty caverns, but rather it is the water that fills empty spaces between soil and rock particles. In some cases, however, materials underlying the surface soil can include easily fractured or eroded rocks, such as limestone. Limestone readily forms deep cracks and caverns. In cases with such a fractured *karst* topography (Figure 14), water will move quickly through underground channels, carrying contaminants as it moves.

Underground water interacts with surface waters when aquifers intersect soil surfaces (Figure 10). Similarly, surface waters interact with groundwaters as water percolates down from ponds and lakes. The sun's heat causes water to evaporate from surface waters, from the soil surface and through transpiration in plants, and the cycle continues. In this cycle, water moves as a liquid, a solid and a gas.

Because water moves through a hydrologic continuum, contamination in one part of the cycle can effect the quality of water in other components. If water picks up air pollutants as it falls to the ground, it can carry these contaminants into surface and groundwaters. Water moving over soil surfaces can carry agricultural chemicals to nearby surface waters. Contaminants in surface waters can percolate down into underlying groundwater aquifers. Consequently, any attempts to protect water quality must be based on recognition that all of these components interact. Otherwise, well-intended program efforts to solve one problem may simply create another. For example, practices that are used to prevent soil erosion may also help protect surface waters. If pesticides are carried on soil particle surfaces, then preventing erosion of particles into lakes and streams will also keep the pesticide out of these waters. However, the very practices that can prevent soil erosion may slow the movement of water over soil surfaces and increase infiltration of water into the soil. If contaminants are being carried in the water, there will be an increased opportunity for contaminants to leach into groundwater.

Most legislation has dealt with parts of this total hydrologic system. Accordingly, USEPA is organized to address different components rather than the total ecosystem. USEPA offices address *air* or *water* or *groundwater*. The agency is not organized to follow movement of particular contaminants through the entire environment. USDA and TVA have historically focused on the effect of agricultural chemicals and nutrients on crop growth. They have studied the movement of these chemicals from application and through the root zone, which is usually about six feet deep (Figure 12). Its only been in the last several years that a number of extensive studies of how these chemicals move through the larger environment have been initiated (Davidson, 1989). USGS has historically focused on movement of contaminants within the saturated zone which is the portion of the soil profile where most of the empty pore spaces are filled with water (Figure 12). Not much work has been done to study movement of contaminants between the root zone and the saturated zone. A "Memorandum of Understanding" between USGS and USDA has defined relative responsibilities of the two agencies, but few cooperative efforts have actually been implemented as of yet.

Separate from the hydrologic cycle, watershed regions are formed from a combination of surface features and underground geology. For example, rain falls on a mountainside and moves into a network of streams and rivers. These watersheds may feed into the ocean, but along the way water percolates down into aquifers that may cover large regions that cross State and local political boundaries. These regional watersheds also need to be addressed holistically. For example, agricultural chemicals may be washed into streams and rivers, which carry contaminants for many miles to lakes, where contaminates then leach into an underlying aquifer. It is not very practical to try and protect the lake and underlying aquifer, without addressing sources of contaminants. Protecting groundwater will require an understanding of major components of total watershed systems. An example of a study of watershed management is diagramed in Figure 15. An earlier attempt to divide the nation up into meaningful water regions is shown in Figure 16. There is little correlation between state boundaries and water resource boundaries, accordingly --

> Ground water protection programs must link local, state, and federal activities into coherent, coordinated action to be effective. Ground water is affected by a wide range of human activities and land uses. Moreover, ground water is affected by and, in turn, affects all other environmental media -- land, surface water, and air. Consequently, a strong, coherent intergovernmental program is essential in protecting groundwater (NRC, 1986).

EPA is organized into major regions, each of which has some degree of autonomous authority. This regional breakdown does allow a greater degree of administrative responsiveness to regional and local issues. However, these regional boundaries are not organized along hydrologic or watershed resource boundaries. On the other hand, USEPA does have some experience in studies based on watershed boundaries. The work done jointly by USEPA and SCS in development of the Rural Clean Water Program should be relevant as pilot studies on movement of agricultural chemicals through watersheds.

TVA was organized partially on the basis of the hydrologic boundaries of the Tennessee River Basin. However, its authorities were extended to include all of the area of the States that contain this watershed region.

Depending on the office, USDA is organized along national, regional, State, and local boundaries, or some combination of these. On one end of the scale, USDA develops national programs to respond to international markets. On the other end of the scale, USDA is involved in developing farm management plans for individual farmers. While USDA's infrastructure is broad, diverse and far reaching, it is usually organized along political rather than natural resource boundaries. However, SCS has recently announced its plans to initiate studies on groundwater contamination within 37 hydrologic areas. These areas were defined as areas of high risk based on SCS's cooperative efforts with USEPA in development of section 319 plans.

Like USDA, USGS works cooperatively with its State counterparts. However, as a technical information gathering agency, USGS has a more extensive history of mapping and studying hydrologic units and underground aquifers as total systems. It may be more administratively comfortable for USGS to develop programs that respond to natural environmental boundaries rather than political boundaries.

The next complicating factor is that most natural resource and environmental boundaries do not coincide. The Resources Conservation Act requires an appraisal of national agricultural resources. To conduct this appraisal, SCS and others developed the Agricultural Resources Interregional Modeling System (ARIMS), diagramed in Figure 17. The ARIMS model examines cropping patterns, and various sectors that impact agricultural resources. The regional areas for several of these parameters are shown in Figures 18, 19 and 20. It is immediately apparent that each of these sectors are unique and not necessarily complementary. In Appendix 5 there is a compendium of charts and graphs of environmental factors that can affect groundwater contamination, which reveal considerable national variations in hydrogeology, surface water systems, soil types, vegetation and cropping patterns, annual precipitation, and annual temperature.

When discussing water *quality*, it may also be necessary to talk about water *quantity*. There are great differences in the amount of withdrawal from underground aquifers (Appendix 5B). In the West, and in arid regions, water *quality* and *quantity* issues are inseparable. The amount of water available to farmers will determine the amount of water used and the methods used to irrigate plants, which has impacts on the ways that contaminants linger or are *flushed* through the soil into groundwater reserves. At present, a number of major western aquifers are being *mined*, which means that underground water is being removed faster than it is being replaced.

In addition to variations in environmental parameters that will affect groundwater quality, there are important variations in important social factors. Today, rural areas provide homes for many who are not farmers, yet they too use rural water wells and can impact groundwater quality. Much of the rural community is inhabited by non-farmers. Agriculture may still dominate the rural landscape, but it no longer controls it. Successful strategies to protect rural groundwater will have to address all rural users as well as developing programs that are appropriate for varied strata of the farming system (Appendix 5C). Different farming systems use different amounts and kinds of agricultural chemicals (Appendix 5D), which will partially determine relative risk of contamination that will occur in vulnerable areas. Numerous studies have already been done to identity extent, severity, and risk of groundwater contamination by nitrogen fertilizers and pesticides (Appendix 5E). Many land and farm management practices have been developed to prevent diverse types of groundwater contamination (Appendix 5F).

Because of these many interacting environmental and social factors, each farmer will have to develop *custom-tailored* management practices to address the many site-specific parameters that affect their production. A groundwater management solution that is ideal for their neighbor's farm may be a very poor option for them. Government programs will have to be crafted to allow for this individuality of needs. On the other hand, each farmer operates within larger ecological systems. Management strategies on one farm in the system may impact the entire hydrologic and ecological system. For example, a particular farmer may decide not to participate in a regional Integrated Pest Management (IPM) program, this individual choice may prevent biological control of a particular insect. As a result, the entire region may have to resort to intensified pesticide applications, which may cause groundwater contamination. Accordingly, individual farm management programs will have to be integrated into the larger context of surrounding hydrologic and ecological systems. At the same time, local and regional needs will have to be balanced against State and national agendas for resource allocations and budgets.

Each of the four agencies will have to develop the capacity to develop national programs that can be administered through hydrologically meaningful regions. At the same time, the goals of these national programs will have to allow for implementation flexibility at the local level. As well, each of the agencies will have to learn to integrate their national, regional, and local programs with each other. As if this were not enough, the agencies will have to accomplish these objectives while working within the context of political boundaries that overlie hydrologic and environmental boundaries.

2. NATIONAL VERSUS STATE AND LOCAL RESPONSIBILITIES

> As states take initiatives to address water quality and agriculture, it will be necessary to sort out federal, state, and local roles more clearly. The need for consistency of standards and equal treatment provide a rationale for a strong federal role. The diversity of farming practice, climate, and hydrogeological conditions suggests the need to tailor to specific conditions (National Governors Association, 1989).

Competition among various levels of government cannot be lightly dismissed when dealing with environmental and resource management issues. Historically, States have had primacy over management of water resources within their boundaries.

> Ground-water management and protection is inherently a state and local responsibility, given the nature and variability of the ground water resource. Decisions on the potential beneficial uses of specific ground waters must be made locally, and many control actions that would be considered for ground-water protection can only be made at state and local levels (EPA/OW, 1988).

Attempts to develop a national groundwater protection agenda about a decade ago were opposed by the States, which did not wish to see their primary authority challenged. Now that funds are much more scarce, and public demands for increased governmental action have increased, there is more of an interest in Federal involvement and support for water quality protection.

The theme that constantly emerges is the need to integrate the flexibility necessary for local site-specific decision-making with consistent national standards and goals. As discussed, each of the Federal agencies have different structures and mechanisms for coordinating national, regional, State, and local efforts.

3. REMEDIATION VERSUS PREVENTION

The advantages and disadvantages of remedial treatment of contaminated aquifers are listed in Figure 21. Prevention of groundwater contamination will be immensely less expensive than attempting to *clean-up* aquifers. In many cases, the technology and science necessary for such clean-up may simply not exist. Preventative groundwater protection, however, is unfortunately like preventative medicine. While prevention is preferred, it is easier to get attention and allocate funding after catastrophies occur.

Some have argued that both strategies should be pursued. Some USEPA planning documents go so far as to suggest that some underground aquifers that are known to be contaminated should be designated as *dumping* areas, while more pristine aquifers should be maintained for drinking water purposes. This strategy presumes that there is a sufficient understanding of underground water flows to say with certainty that contamination in one region will not move into another.

Each agency could have a role to play in remediation and prevention. USGS would work on fate and transport sciences necessary for either approach, though it is less likely to work on *clean-up* technologies. USDA and TVA have greater resources to support programs that prevent groundwater contamination than they have to facilitate clean-up after the fact. The development of mandatory controls and regulations through USEPA may be a necessary component in contamination prevention but USEPA also has more interest and experience in *clean-up* technologies than the other agencies.

4. MANDATORY VERSUS VOLUNTARY PROGRAMS

A summary of relative advantages and disadvantages to mandatory and voluntary approaches to groundwater protection is provided in Figure 22. At this time, the Office of Management and Budget has emphasized development of voluntary programs. Part of their rationale is based on economic considerations. The use of taxes, fees, or regulations will result in increased costs to farmers. Given current market structures, farmers cannot readily pass increased costs along to consumers (Offutt, 1989). Voluntary research and education programs are seen as a form of *cost-sharing*, whereby costs of protecting the environment are shared by the general public, rather than by placing the economic burden on producers alone.

Whether a regulatory or a voluntary approach is taken at this time, research will have to be done and farmers will have to be provided with educational programs and technical assistance. Accordingly, TVA, USDA and USGS should have strong research and education responsibilities whichever strategy is pursued. USGS does not want to be included in regulatory programs. USDA and TVA have greater experience in outreach, technical support and the requirement of compliance with government programs, but both are wary of direct involvement in enforcement programs. USEPA, of course, has much greater experience in enforcement and regulatory programs. USEPA has demonstrated a repeated interest in participating in education, outreach, and demonstration programs and has some degree of experience in each of these areas. However, USEPA lacks the outreach communications infrastructure and personnel present within USDA's SCS and ES. On the other hand, USEPA may have critical information on pesticide management and handling that currently is not communicated to producers. Efforts to establish linkages between USEPA and USDA's ES have been tried, but differences in administrative structure and general wariness by both agencies has impeded more successful cooperative ventures. USEPA staff have voiced frustration at not being able to move ahead with education materials that have been developed, and ES staff have complained that contractors working for USEPA develop materials independently and contrary to previous agreements.

Many members of the research and Extension communities would prefer to develop an adequate research base and educational infrastructure before regulations are implemented (Nipp, 1989). This is due in part to the tremendous environmental variability that has been discussed. For example, a farm that has clay soils and a very deep groundwater table will not be at the same risk of nitrate contamination from nitrogen fertilizers as a farm on sandy soils and a very shallow groundwater table. An *across-the-board* regulation that limits both farmers to the same fertilizer application rates and techniques would be nonsensical and could be counter-productive. Regulations should be based on actual environmental parameters that will determine environmental risk, and this will require greatly expanded research efforts.

Some combination of voluntary and regulatory programs may prove ideal. In Nebraska, Natural Resource Districts (NRD's) have been identified based on hydrologic units and watershed regions, rather than political county boundaries. There was considerable resistance by county governments when these districts were first created. However, the existence of NRD's have made it possible to develop a *tiered* protection program, based on actual risk to the environment. In districts where contamination is low, education and voluntary programs are emphasized. In districts with higher contamination or risk, farmers may be required to participate in certain programs. In one district with high nitrate contamination problems, a farmer must show receipts for having attended a nutrient management program before they are allowed to purchase nitrogen fertilizers. In the case of severe contamination, use of particular agricultural chemicals may be banned altogether.

In such a tiered system, decisions are made on the basis of actual risk to the environment, based on environmental parameters. In this sort of system, there could be a role for each Federal agency, though they would have to be carefully coordinated and well defined.

5. RESEARCH VERSUS EXTENSION EFFORTS

It is important that necessary data is available so that regulatory programs, should they be developed, can be implemented on rational grounds. Some have gone so far as to argue that it will be necessary to wait for 10 years so that the movement of agricultural chemicals through the environment is sufficiently

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understood before extension, education, and technical assistance programs are implemented. However, there is a tremendous amount of information on water quality protection that can be communicated now, and there are management practices to protect water quality that need to be implemented now. It is true that there are gaps in the research and knowledge base that need to be addressed. As results of research efforts become available, it needs to be readily incorporated into ongoing education and extension efforts. However, there is no need to wait. Extension agents argue strongly that there are research has already provided information on many farm management practices that need to be communicated to farmers now, practices that can have a significant impact on reducing groundwater contamination.

C. ORGANIZATIONAL STRUCTURES AND THE MANAGEMENT OF INFORMATION AND UNCERTAINTY

> Institutional arrangements, including laws, organizations, regulations, and enforcement mechanisms, all play a critical role in determining which water quality control strategies are employed and the effectiveness of those strategies. There is currently little research focused on the efficacy of various institutions which are available for use in preserving water quality (Univ. of Calif. Task Force, 1988).

In the preceding discussions, it has been pointed out that USEPA, TVA, USDA and USGS have different organizational structures and that these difference may have an impact on how well they can respond to different kinds of problems. Each agency comes to the issue of groundwater protection bearing different organizational tools and historical resources. Each agency will be inclined to address groundwater protection using tools with which they are familiar. However, will available tools be the best tools? Should there be instead some *retooling*?

To evaluate the adequacy of the agencies' current organization structures, there must be a working model of an ideal structure against which they can be compared. A considerable body of thought has evolved in academic circles that study organization theory, organizational development, and systems engineering. It is not feasible to outline here the fundamentals of these various disciplines. However, these schools will provide conceptual foundations for the evaluation that follows, with particular use of the ideas developed by Galbraith (1973). At this point, it would be helpful to iterate characteristics of an ideal organizational structure for agencies with groundwater protection programs. Unfortunately, it is not clear what this list would entail. As an alternative, some characteristics of an ideal structure will be developed using some fundamentals of organization theory. Some critical issues will be addressed, including: an examination of the relative merits of organizing groundwater programs using a *project* or a *functional* structure, whether it is best to involve program participants on a full- or part-time basis, whether new administrative coordinating mechanisms need to be established, and what mechanisms can be utilized by agencies to successfully respond to uncertainties in their program development.

To begin, organizational structure is much more than official hierarchy represented in organizational charts. Charts are helpful in breaking responsibilities up into manageable pieces. They can serve as a necessary first step in keeping track of who has what authority to address which issues, just as they have been used here. However, an unspoken and more powerful social structure often supersedes formal structure. People talk to people, even when their *boxes* are not connected by arrows. If they did not, many problems would become unsolvable. As agencies attempt to address increasingly complex problems, it will be necessary to combine resources and expertise of individuals in previously distinct organizational units. Official hierarchical structure may remain necessary to maintain functions of the organization, and to maintain order, but *ad hoc* committees and working groups will increasingly cut across main line administrative authorities. Ideally, an organization's structure will facilitate rather than hinder communication between units that need to cooperate, so that resources necessary for completion of intra-agency tasks can be linked and harnessed. Formal and informal communication linkages develop among organization units to facilitate this communication. Both forms of communication are crucial for survival and functioning of the agencies.

Some organizations emphasize their *hierarchical* or *functional* structures. For examples, universities are organized along *functional* academic disciplines. Other groups emphasize *problem solving* and bring together experts from different disciplines to address specific topics cooperatively. This is similar to the multidisciplinary and interdisciplinary working groups that universities use to cross disciplinary boundaries. What is the optimal balance of functional vs. project-oriented organizational structure? A study on this question was conducted by the Sloan School Project on the Management of Science and Technology (Galbraith, 1973). Aerospace firms that develop *hi-tech* products for the government were examined.

This study determined that firms with technical personnel organized on a functional basis produced projects that were technically superior to those produced by firms that organized their personnel on a project basis. This result may be surprising. Some might expect that better products might be produced by grouping diverse but appropriate personnel on specific projects, regardless of their disciplinary or institutional affiliation. However, it appeared that continued contact with peers enhances technical performance and competence.

The same study showed that firms that organized administrative personnel on a project basis provided better support services and were more likely to meet their cost and schedule targets. The *multidisciplinary* approach did not produce technically superior products, but it did provide better incorporation of broader social and economic concerns. However, these project oriented groups had to have access to *vertically integrated information systems* to produce superior responses. Such information systems ensured that members of project groups had access to the flow of information within their *home* offices.

The organizers of this study concluded that firms should use a combination of these organizational strategies to create high technology products on tight schedules. They concluded that technical personnel should be organized on a functional basis. However, they felt that project-oriented offices should be established for administrative personnel. These administrators would need to be supported by a project-related information system.

This study should have relevance to groundwater protection programs. Within each agency, there are scientists and technical specialists within separated offices. In universities, the analogy is particularly apt, as technical experts are housed in separate disciplines and departments. The merit of this functional structure is that it facilitates communication between technical peers and enhances their resources and capabilities. Soil scientists working on herbicide movements through the soil profile have access to each other. Plant physiologists examining the amount of a herbicide necessary to disrupt electron transfer in photosynthesis so a weed is killed, again have continued access to each other. Technical competence is enhanced. The problem is that these two groups have to come together to develop a herbicide application strategy that will kill weeds without excess herbicides moving into groundwater. A project-oriented structures is therefore also necessary.

Applying the Sloan study, the respective scientists should be left in their functional homes. However, program administrators should be organized into project oriented task groups to coordinate their technical experts on a project-by-project basis. It is also important that administrators of groundwater project are not too far removed from technical aspects of their programs, or they simply will not understand the context of decisions that have to be made. These administrators must have access to information that is critical to decisions at hand, and an understanding of *real world* consequences of their decisions:

> If all the Department of Defense task force studies were separated into those that were implemented and those that were discarded, the discarded task force studies would be characterized by exclusive participation of staff groups and outside consultants. It is not that these groups are useless but that they lack the insight of the man who has the original problem and commitment from the man who has to make it work (Galbraith, 1973).

Numerous *multidisciplinary* and project-oriented groundwater protection task groups already exist, in universities and within agencies. There seems, however, to be concerns in the environmental community and in Congress that not enough of this problem-oriented multidisciplinary and multiagency work is being done, or that it is not being done properly.

A simplified organizational model of agency offices involved in groundwater protection is shown Figure 23. It would be difficult to keep track of all pertinent offices, so a *sampling* has been selected for discussion purposes. The study of the herbicide Atrazine will be used for discussion purposes. Within each agency there is expertise on the movement of Atrazine in the environment. These experts might be contracted through USEPA's Office of Environmental Processes and Research, or the Office of Water Quality. Scientists might also be located at TVA's National Fertilizer Development Center. There are scientists housed at USDA's Agricultural Research Service, through the Cooperative State Research Service at State Universities and Land Grants, and through the Extension Service. There is also expertise housed in USGS's Water Data Coordination Office. Rather than each office developing programs to study Atrazine independently of each other, it makes intuitive sense that appropriate scientists should be working together to coordinate their efforts and resources. They should at least be aware of each others efforts. A *Management of Atrazine and Groundwater* (MAG) working group could be established to facilitate interagency communication.

Some might assume that communication between scientists studying Atrazine will happen naturally. After all, scientists are always going off to conferences to discuss their work with each other. True, but they are usually going off to talk with other scientists within their own disciplines. A number of different disciplines may be involved in the study of Atrazine movement, including chemists, physicists, engineers, geologists, plant physiologists, soil scientists, agronomists and so on. These scientists may or may not be aware of the activities of their counterparts, who publish is separate journals and attend different conferences. If these scientists are also housed in different agencies, they may not be aware of each other's activities unless some form of ad hoc of working group is formed.

If the MAG group is to go beyond sharing information, and actually starts to develop jointly-planned and implemented projects, then the working composition of the multidisciplinary and multiagency MAG group should be properly determined. If all participants in MAG are dedicated to the project full-time, the specialists lose contact with their peer groups. If all participants work on the project on a part-time basis, they can become disassociated from project goals and provide only minimal contributions. Again, some combination of approaches is necessary. In a study of the overall technical, cost and schedule performance for 37 projects performed for the Department of Defense and NASA, it was determined that a small core of full-time people and a majority of part-time participants produced optimal performance (Galbraith, 1973). The smaller working group provides coordinated focus to get work done, and the larger group provides a breath of perspective.

It is relatively easy to organize scientists into working groups to work on specific projects such as MAG. It is more difficult to coordinate implementation of programs already underway within their respective agencies. If each Federal agency is already implementing programs to protect groundwater from Atrazine contamination, the MAG group will be insufficient. The researchers may agree as to what needs to be done, but they rarely have authority to resolve administrative, bureaucratic or budget differences that will develop among their agencies. Additional mechanisms will have to be used, including:

- Direct contact between program managers within the respective agencies that have comparable groundwater protection projects.
- Administratively approved mechanisms to establish temporary groups and task forces to solve short-term management problems affecting several groundwater protection offices.
- Identified individuals with established liaison roles to link the pertinent groundwater protection programs.
- Permanent groundwater program *administrative groups*, to resolve constantly recurring inter- and intra-agency administrative problems, made up of appropriate budget and administrative personnel.
- For each of the cooperative or coordinated groundwater protection programs, an individual with a defined *integrating role*, should be identified to resolve questions regarding coordination.
- At times, facilitating coordination will not be sufficient and some individual with managerial resources and authority will need to be defined to act as the *integrator* and *moderator* when there is substantial conflict or differences among agencies.

Once established, it is natural that there should be occasional friction between groups such as MAG and the traditional lines of administrative authority within the agencies. The activities of groundwater protection coordinating groups must be shown to be important by administrative heads and a clear reward system for participation must be demonstrated. It is also important that participants in groundwater protection groups have authority to commit their offices and agencies to agreed upon actions.

There are two fundamental errors that project-oriented groups, such as groundwater protection groups, can make while seeking to resolve disputes among their members. One error is to let conflicts culminate in group fragmentation and loss of its coordinating function. To avoid this, many groups commit the opposite error of developing program agendas that are so vague and ill-defined that they are unlikely to offend anyone. However, vague program plans are unlikely to actually resolve or accomplish anything either. An ideal solution might be to be develop programs as precisely as possible, compromise when needed, and allow for airing of dissenting opinions as a safety valve. However, an endless series of incremental compromises may obscure some fundamental problems that need to be resolved (Galbraith, 1973). Not all conflict is bad. It is sometimes necessary to allow a *contained conflagration* in order to trigger a search for new alternatives.

As agencies develop project-oriented coordinating groups to develop and implement groundwater protection programs, it will be necessary to adapt to a new level of *uncertainty* in developing their programs. One of the most critical organizing principles that distinguishes successful organizations from those that fail is how they organize to deal with such uncertainty:

> ...the greater the uncertainty of the task, the greater the amount of information that has to be processed between decision makers during its execution. If the task is well understood prior to performing it, much of the actual activity can be pre-planned. If it is not understood, then during the actual execution of the task, more knowledge is acquired which leads to changes in resource allocation, schedules and priorities. All these changes require information processing during task performance. Therefore the greater the task uncertainty, the greater the amount of information that must be processed among decision makers during task execution in order to achieve a given level of performance (Galbraith, 1973).

In traditional functional divisions, the scope and dimensions are relatively well defined. Soil scientists studying Atrazine movement in the root zone have difficult questions to answer, but they do know what some of the critical questions are. When they attempt to coordinate with other scientists and other agencies to address more comprehensive problems, there is a much higher level of uncertainty over what needs to be done and how the participants can plan to address the problem. Moreover, there is greater confusion over the research-development-implementation process itself. Traditionally, as argued by Don Holt (1989b), problems are first addressed at the level of *basic* research, where fundamental processes are examined (Figure 24). The results of basic research are picked-up by scientists doing developmental research, who apply the fundamental concepts developed in basic research to specific problems. Once solutions to problems are developed, adaptive research studies how these results can be applied out in the real world. After developing applications of the research, the new technologies are transmitted to the outside world.

Unfortunately, the traditional research-development- implementation process takes a long time. The research community is trained to follow this process. Moreover, the research community is trained to wait until they have research results that have a *95% degree of confidence* of being correct before they say anything. The general public appears much more impatient. Applications of new technologies are wanted in a year or two, not in 10 or 20. The outcome is that some programs are being developed to disseminate *research* results that may be inadequately tested or confirmed. Some traditional scientists are horrified at support of new agricultural production practices to protect the environment that appears to them to be based on anecdotal evidence. And truthfully, if these technologies fail, as some of them inevitably will, an annoyed public will fault the scientific community.

This is a more complex and difficult issue than there is time to explore fully here, but the fundamental issue that has to be addressed is how should the agencies balance between the short-term need for new technologies to protect groundwater that can be implemented now, and the need for fundamental research programs to develop new technologies? Holt proposes one solution, which is to try and apply the concepts of *parallel processing* developed in computer processing (Figure 25). In this system, each of the traditional research and technology transfer processes would begin simultaneously. As results become available, each of the four components would provide information to each other, rather than wait for a sequential flow from one to the next. Applying this system to groundwater protection, it implies that technology transfer should be initiated immediately, using the best that is known now, with the realization that as better tools become available they will supersede earlier recommendations. It also means that the agencies will have to be prepared to develop technology transfer programs in advance of knowing what all of the tools are that they will have available. They will have to develop the communication and education infrastructure, and add to it as new tools are developed. Similarly, developmental research projects may be well down the road when a new discovery in basic research makes ongoing developmental work obsolete. The agencies will have to become more facile at reallocating resources and priorities when this happens.

All of the processes that have been described already happen. The difference is that *parallel processing* of programs will cause these difficulties to surface more quickly. The agencies will have to plan for their programs to have sufficient agility to grow and develop as new results develop.

Looking at the *sampling* of agencies that could be involved in a coordinating a groundwater protection project such as MAG, Figure 26, it becomes apparent that applying parallel processing to speed up program implementation could become very difficult administratively if several agencies are involved. Each office could independently work on all four research and technology transfer components, then try to coordinate each of the four with all other offices. The interconnecting lines that would have to be added to Figure 26 would obliterate the outline of the agencies. Another alternative would be for each office to deal with only one component of the four, such as applied research. Then all of the offices conducting applied research could coordinate with each other, and communicate with the other components. The mandates of most of the offices, however, will require that they are involved in the full array of the four components. The last alternative is for the offices to coordinate on a project-by-project basis, and to coordinate the parallel processing of the agencies within the context of each project.

Once assigned, the participants of an intra-agency coordinating working group to develop and integrate groundwater protection programs may have to face two different kinds of problems. On one hand, the particular problem they are organized to address may be fairly well-defined. If so, and there are offices with well-defined responsibilities to address the known components of the problem, then program development can follow the somewhat mechanistic forward process of recursive planning, outlined in Figure 27. An application of such recursive planning to developing a program to protect groundwater, combined with parallel processing, is shown in Figure 28.

The program development process outlined in Figure 28 is fairly simple and ideal, the problems develop as each of the involved offices try to coordinate the different bits and pieces that they have to contribute to the entire process. The process becomes even more complicated when the problem to be addressed is not well defined, and if there is confusion over which offices have the expertise or authority to deal with different aspects of the problem (Figure 29). There are two *loops* that can greatly slow program development under such conditions: the *Somebody else's problem* loop and the *Do we want to deal with this?* loop. As shown in Figure 29, the assignment of responsibilities can be kept circulating until a program administrator with sufficient authority explicitly defines the program to be within the domain and interests of the involved offices. Once defined to be of interest, the assigned individuals within the offices have to feel their way around as they try to get a sense of what the program objectives are, what is already being done and where, and how to design and implement programs that will meet their objectives. The evolution of programs in such a poorly defined environment can be haphazard, slow, tedious, and frustrating. The critical factor in developing a successful program under these conditions is to recognize the conditions for what they are, and to organize to address the uncertainty that exists.

One way to plan to develop an organization response to uncertainty has been developed by Lisa Carlson, Billy Lemon and Frank Burns (1987) of the Metasystems Design Group (Appendix 6). They suggest the development of the use of a *Scan-Focus-Act* (Figure 29) process to develop *Excellence Networks* (Figure 30). They presented this concept in a discussions on the Metannet computer bulletin board system, which has been adapted for this discussion to apply more specifically to the development of programs to protect groundwater (Carlson, Lemon and Burns, 1989). The Metasystems group argue that organizations can be reactive, responsive, proactive, or high performance (Figure 30.1). Since each of the agencies have been accused of being *reactive* on the issue of developing groundwater protection programs, the Metasystems arguments are particularly germane. They state that organizations need to:

- escape the traps of being reactive and behind the proverbial power curve of technological and social change,
- become responsive in adapting -- competently -- with the changing world,
- take a proactive role in choosing change and making change happen,

- and focus on achieving the highest levels of performance and human potential.

They suggest that groups struggling to define their mission and agenda need to go through the simple *Scan-Focus-Act* process outlined in Figure 30.2:

Scan: start with an open exchange of information about current realities and future opportunities;

Focus: follow with discussions and decisions on overall purpose, outcomes, objectives;

Act: conclude with clarification on who's going to do what, when.

These steps may seem obvious, and they should be, but many groundwater protection groups have struggled to implement this simple sequence. On reflection, it should not be surprising. While there are many programs and schools of thought that have developed regarding the social dynamics of meetings, it appears that few in the technical or research communities have every received such training. Excellent researchers are promoted to become program leaders, though few have any training in administration. Most try to make up the deficiencies in their training on their own, and some do very well, but many are left without fundamental training in social dynamics, program administration, organizational behavior, or systems design. This should not be seen as an indictment against the research community, because it appears that many groups also lack the same fundamental organization training.

The *Scan-Focus-Act* process act should result in the coordination of previously isolated experts (Figure 30.3) into an integrated team to address a specific set of problems (Figure 30.4). Once the core group defines its mission, it needs to refine its organizing principles and expand its activities to encompass a broader array of experts (Figure 30.5). Once the larger group of experts is gathered, they need to be assigned to *focus groups* to address specific problem areas (Figure 30.6). A *weaver team* needs to integrate the products of the focus groups into the overarching goals of the total project (Figure 30.7). The programs developed by the group then need to be adopted and supported by the respective office and agency administrators (Figure 30.8).

Again this *Excellence Network* concept may seem a basic model for what should happen naturally. As such, it can serve as a measure of the adequacy of the processes leading to the development of current groundwater protection programs. It remains to integrate the concept of parallel processing for projects into this model. As shown in Figure 31, parallel processing could occur within the focus groups. For planning and program development purposes, this process should not be too difficult. However, the experts may have difficulties as they try to integrate the implementation of their coordinated agenda within their respective agencies.

II. SOME PROBLEMS

In the earlier review of agency activities it was shown that there is a high level of interest and program development to protect groundwater on the part of USEPA, TVA, USDA and USGS. As a result of the President's Water Quality Initiative, for example, it appears that about $40 million in new funds will be directed through USDA to develop new water quality protection programs in fiscal year 1990. Within all of these agencies, there appears to have been active program development and generation of planning publications, as indicated in Appendix A2. Further, a remarkable increase in interagency coordination has occurred, as stated by the Assistant Deputy Secretary for Science and Education, USDA:

> This is exemplified in our planning for the Midwest part of the Water Quality Initiative. USGS and EPA have been represented on planning teams and we have coordinated our efforts with the USGS Midcontinent Initiative. Some research sites for these major efforts will be co-located, thereby avoiding duplication while at the same time increasing the amount of information developed (Mussman, 1989).

Notwithstanding this increase in agency efforts, there is still considerable concern, in the environmental community and in the public sector, that federal actions are insufficient:

> Along with the diversity of causes, we also find a diversity of existing Federal and state authorities to prevent, detect and correct groundwater contamination. At least eight major Federal laws speak

> to the issue of groundwater to some extent, and within each state it is possible to find as many as seven agencies dealing with groundwater issues. But while the states write 'strategies' and the lawbooks provide us with a great many pages of text devoted to groundwater, there are hundreds of communities across this country with citizens who will attest to the failure of those laws, the associated regulations and enforcement mechanisms that are supposed to give their groundwater adequate protection (Smith, 1989).

Clearly, many in Congress are not satisfied by current federal efforts to protect groundwater. In recent Congressional hearings jointly held by the Subcommittee on Natural Resources, Agriculture Research and Environment (House Science, Space and Technology Committee) and the Subcommittee on Department Operations, Research and Foreign Agriculture (House Agriculture Committee), Subcommittee Chairman James Scheuer (D-N.Y.) vigorously attacked what he called the "thundering indifference" of USDA, USEPA, and USGS (Scheuer, 1989). Either the federal agencies are failing to communicate to Congress the dimensions of their new efforts, or Congress is simply unimpressed with the scale and the extent of these programs. In a world where "perception is reality," the Congressional perception of inadequate Federal agency actions will likely result in legislation that mandates increased federal effort and coordination. In the context of the preceding discussion of ideal organizational mechanisms to develop groundwater protection programs, the following section provides a discussion of the kinds of problems that Congress might wish to address.

A. GOALS

> *"Would you tell me, please, which way I ought to go from here?"..".That depends a good deal on where you want to get to," said the cat..".I don't much care where -" said Alice..".Then it doesn't matter which way you go," said the Cat..".- so long as I get somewhere," Alice added as an explanation..".Oh, you're sure to do that," said the Cat, "if you only walk long enough".*
>
> -- Lewis Carroll
> Alice in Wonderland

It is difficult to hold the Federal agencies accountable for not having reached specific groundwater protection goals when they have not been given specific goals to reach. Each of the agencies being considered here -- USEPA, TVA, USDA and USGS -- have program statements regarding their intent in the area of groundwater protection, but none of these agencies have a mandated set of specific and measurable goals.

Using the working definitions of the Congressional Office of Technology Assessment, a *goal* is a state to be reached at an identifiable date towards which progress can be measured. Using this definition, a 50% reduction in pesticide use by the year 2010 would count as a goal, while providing high quality food at reasonable prices is not a goal but an objective. Much of the unhappiness between the Federal agencies and the Congress might be attributed to the fact that the directives that do exist are so vague that Congress can conclude that they are being ignored at the same time that the agencies conclude that the directives are

B. LEADERSHIP

1. ASSIGNED LEADERSHIP RESPONSIBILITIES

Related to the confusion over agency goals, there is confusion over *leadership* within and among the agencies. This confusion has been exacerbated by the delays in the appointment of key personnel under the new administration. As of this writing, almost a year after the last presidential election, the Assistant Secretary for Natural Resources within USDA has not been appointed. In the absence of leadership at the top, some leaders within the Soil Conservation Service have privately expressed a reluctance to develop or implement groundwater protection policy, for fear of heading in a direction contrary to the preferences of the new leadership. A number of offices within each of the agencies have struggled with a similar *leadership* vacuum. Whether this leadership vacuum is the fault of the administration, Congress, or interest group conflicts is outside of the scope of this paper, but it is within the domain of this paper to note that there have been problems in leadership and that this may have an impact on the development of groundwater protection programs.

Apart from any internal leadership difficulties, there is the question of the appropriate leadership roles among the agencies. In hearings on groundwater quality held in the 100th Congress, an issue that was often raised was which of the Federal agencies should be the *lead agency* on groundwater protection. USGS proponents pointed out their extant *lead agency* status for groundwater data collection and coordination. USEPA proponents argued for the need for regulations and enforcement. Initially, USDA did not appear enthusiastic about taking *lead agency* status, although there was a stated willingness to *lead* when agrichemical contaminants were involved (Long, 1987). Since that time, directives from the Office of Management and Budget, continued Congressional inquiry and a change of leadership have evoked a more enthusiastic response by USDA (Hess, 1989).

Actually, the question of which agency should be the *lead agency* reflects an inadequate understanding of groundwater contamination issues. In an interagency report on water resource management for programs conducted by the Tennessee Valley Authority it was stated that

> The diversity and extent of these resource problems create technical, financial, and institutional disincentives for even the most ardent resource managers. Considering the size and complexity of these issues, it is easy to see why comprehensive and sustained progress has been elusive. The problems are simply to big to be solved by a single program, agency, or legislative act. Resources are obviously needed to strengthen these individual elements, but a coordinated and comprehensive effort is also required (TVA, 1988a).

Rather than deciding on a *lead* agency, it might be more appropriate for Congress to assign specific domains of groundwater protection responsibilities to each of the agencies, to complement the assignment of specific goals. As discussed in the introduction of this paper, each of the agencies have unique areas

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of expertise that should be harnessed and directed. USEPA should clearly have a lead role in establishing standards and developing regulatory structures. TVA has a reservoir of technical expertise in nutrient management housed at the National Fertilizer Development Center and unique access to fertilizer dealers and associations. USDA has expertise in the areas of crop and farm management, education and technical assistance to farmers, and ongoing research on the fate and transport of agricultural chemicals and nutrients from application through the root zone. USGS has responsibilities in the mapping of underground aquifers, groundwater data collection and research on the fate and transport of chemicals through the saturated zone. In the last several years, 'memoranda of understanding' (MOU's) have been signed between the respective agencies to help clarify their respective roles in groundwater protection. Unfortunately, these memoranda of understanding are usually quite vague and they do not develop specific guidelines for the actual integration of program efforts.

2. MISSING AUTHORITY

The authorizing legislation for most of the agencies is so broad that, in general, no additions in authority are needed for them to fulfill their respective missions to protect groundwater resources. However, additional authorizing legislation could serve to give agencies specific directions and priorities within their broader range of activities and legitimize their activities.

Some gaps may exist, however, in the authority of USEPA. Since it lacks the broad organic authorities provided to the other agencies, USEPA has less flexibility to develop programs in the absence of authorizing legislation. Moreover, by their nature, regulatory programs require specific authorizing language. Out of the many authorizing laws pertinent to groundwater protection cited in the beginning of this paper, there is little clear authority for USEPA to regulate privately owned drinking water wells, their authority is limited to public water systems. Pertinent to groundwater protection, if USEPA found that fertilizer applications were causing severe nitrate contamination of private water wells, it would have little basis for intervention. USEPA is authorized to support the development of State plans and programs, which could include nutrient management programs. USEPA is authorized to develop demonstration programs, which might happen to include nutrient management. However, USEPA has little basis for developing regulatory guidelines to prevent or contamination of private water wells by agrichemical nutrients.

3. FRAGMENTED AUTHORITY

A far more perplexing problem than developing adequate agency authority to protect groundwater is fragmentation and overlap of existing authority. As discussed in the beginning of this paper, water quality concerns are addressed in a number of separate pieces of distinct and often uncorrelated legislation. The failure to integrate the provisions of these distinct laws into an coordinated set of statutes may lead to problems and conflicts in the implementation of these laws. By way of example: since anhydrous ammonia fertilizer can volatilize into the atmosphere, be washed into surface waters or percolate into groundwater, the use of this fertilizer could be covered not only by the diverse groundwater protection provisions already enacted, but also be regulated by laws to protect surface waters, air pollution and the global climate. The time is coming when a farmer that applies fertilizer on a field may have to comply with the provisions of more than a dozen separate pieces of legislation. The demands of each of these separate Acts could require different and sometimes contradictory behavior.

In an ideal world, Congress would require the creation of a *blue-ribbon* committee of lawyers, administrators, and scientists to evaluate current water quality laws, to identify areas of conflict and overlap, and to suggest legislation that would integrate already existing laws into a rational and consistent structure. A variant would be to pass an omnibus water quality bill that encompasses earlier legislation, but incorporates it into a rationally consistent structure. However, each approach would require the integration of laws that were developed and supported by separate committees within Congress. Each of these committees respond to different constituencies, each has a different set of priorities, and sometimes there is fierce competition between the committees for jurisdiction. A comprehensive, integrated and rational set of groundwater laws may be difficult to create in this environment.

In addition to potential confusion between groundwater protection laws, there are some jurisdictional issues involving the agencies that should be resolved. For example, USEPA has appropriations and authority to conduct pesticide applicator training programs (PAT), but USEPA lacks the rural infrastructure and communications network necessary to deliver the program. Consequently, USEPA contracts out with USDA/ES, which has the delivery infrastructure but lacks funds and mandates. Since its implementation, funding for the PAT programs has declined dramatically. In an era of tight budgets, neither USEPA or USDA seems interested in making the necessary investments in a program where their respective responsibilities and authorities appear vague. Recent studies of the PAT program are included in Appendix 7.

A comparable problem exists in the development of State groundwater management plans to comply with USEPA's Section 319 programs. SCS has been working with USEPA in the development of the 319 plans, but other State and Federal agricultural agencies were involved in varying degrees in development of agricultural management components of these plans. The adequacy of the agricultural components may vary tremendously from State to State. An option for Congress would be to require that appropriate State and Federal agricultural agencies cooperatively review the agricultural components of each State's groundwater protection plans. Appropriate agencies would include ARS, CSRS, SAES, ES, USGS, TVA and State Departments of Agriculture.

C. PROGRAM MANAGEMENT

1. PROGRAM COORDINATION

> There are approximately 16 different federal agencies that have some responsibility for regulating and protecting groundwater. Intergovernmental communication and cooperation is essential to this effort! (Maslin, 1989).

Many of the administrators involved in the development of current agency groundwater protection programs state that more interagency cooperation is underway to address groundwater protection than has ever occurred before. There remain, however, criticisms that some of the programs are redundant and that some critical areas are *slipping through the cracks.*

Without clearly defined areas of responsibility and accountability it is natural that there will be some duplication of efforts. Actually, some duplication may be desirable, as a way to *check the system* (Stiles, 1988), but at the same time a wasteful duplication of basic functions and responsibilities should be avoided. Three or four *super-agencies* that do everything and compete with each other for project funding will not be as efficient as 3 or 4 agencies with specific responsibilities and specialties that can be coordinated in the development of

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super-programs.

Insufficient coordination can result in lost opportunities to benefit from the findings of related programs. For example, agricultural scientists have studied the effect of plant nutrients on crop yields for years, but usually these experiments did not include measuring the movement of applied nutrients through the surrounding environment. It was commonly believed that micro-organisms and filtering properties of the soil profile would eliminate or break these compounds apart before they reached the groundwater table. For years, in separate studies, the Department of Agriculture sponsored studies on movement of agricultural chemicals from the soil surface through the root zone, but they rarely traced chemicals past the root zone (Davidson, 1989). Meanwhile, USGS has been studying movement of chemicals into the *saturated zone*, from the groundwater table on down (Ragone, 1989). There was considerable confusion over who, if anyone, was studying movement of chemicals through the *vadose* zone, the region between the root zone and saturated zone.

It is important to realize that each agency was properly doing research within its authorized domain of interest. They were doing what they had been created to do. But a moment's reflection makes it clear that to study the impact of agricultural chemicals on groundwater aquifers would require tracing chemical movement from application, through the root zone, through the vadose zone and groundwater, and so on. Despite the potential synergy that could result from careful and strategic integration of these distinct programs, there is yet little coordinated planning.

USDA is supportive of the concept of coordinating these programs, as evidenced by the quote in the earlier section on USDA programs (USDA, 1989e). Program administrators involved with the projects and are aware of each others activities, but at this stage there is yet little coordinated planning of program agendas. Actually, it is premature to expect too much in the way of coordinated planning. New funding to specifically address water quality concerns only began last year. However, there are great opportunities to be explored that should not be missed. The question remains, are there sufficient coordinating and planning mechanisms in place to ensure that the opportunity to integrate these programs is not lost? If the coordinating mechanisms are sufficient, is there sufficient administrative impetus to require the coordination of these programs?

Another example of the importance of detailed coordination is provided by the selection of sites to study groundwater protection problems. Other offices in USDA had anticipated coordinating with SCS in their selection of 37 hydrologic units for water quality studies. A number of USDA staff were quite startled when the selection sites were announced, prior to any input from their offices. Similarly, some University personnel were grumpy over the fact that the Extension

Service selected 8 demonstration sites for water quality programs, and then elected not to use extension funds to support fate and transport research on demonstration sites. The scientists rightly feel that it is important to study fate and transport on the demonstration sites to identify which practices are in fact more environmentally benign. The Extension Service rightly noted that they do education, not research, and that the proposed fate and transport work is extremely expensive. The Extension Service is willing to allow fate and transport work, but they do not want to pay for it. All of these are very understandable *start-up* difficulties, but they need to be addressed so that they do not develop into lost opportunities.

Yet another example: USEPA allocated $7 million out to their state designated agencies to programs relevant to water quality protection, including $5 million for education programs, $1 million for worker safety, and $1 million for endangered species. Some USDA Extension Service staff complained that apart from a preliminary discussion among the agency administrators, there was little detailed coordinated planning between the agencies on how to best direct and use the education funds. These staff allowed that it might "just be a case of the right hand not knowing what the left was doing," that perhaps there was more discussion than they knew of, but they "were inclined to take a more paranoid view."

Another area where possibilities for increased coordination should be examined lies outside of the agencies. A tremendous amount or relevant work is being conducted by industry and public interest groups. Monsanto has spent millions of dollars monitoring the movement of some of their products in the environment. Monsanto and Dupont have developed high quality video and education materials on pesticide management and handling. Public interest groups have developed farmer decision aides, alternative production practices, and educational materials. There is obviously going to be problems in using the materials developed by the diverse groups that have vested interests. The agencies will have difficulties using materials developed either by industry or the environmentalists, for fear or appearing biased on one side or the other. As a case in point: agricultural scientists have long been accused of being *bought out* by the chemical industries, because some received research funding from the industries. Some industry representatives are now complaining that researchers are being *bought* by the *lure of funding* to do *low-input* research. It is appropriate, in our system, to maintain a healthy mix of opposing views, which will hopefully balance out to support the creation of rational programs. However, mechanisms need to be developed for the agencies to capture and use the excellent resources that are being developed outside the agencies. Too much good work may otherwise be wasted, or have to be duplicated.

2. PROGRAM INTEGRATION

At present, agency administrators appear to be very supportive of increased coordination between their agencies. However, because of the sheer volume of details, agency administrators have to agree about fairly broad generalities, they cannot work out the integration of individual programs. On the other extreme, there are many instances of scientists from different agencies working together under joint-funding to address very specific groundwater research issues in university field studies. Coordination, as such, is relatively easy. The difficult task is *integration*.

The agencies know how to run coordinated site-specific programs. The agencies are already working to coordinate broad national objectives. The hard part is at the intermediate level, where broad national objectives and specific details have to be integrated by program administrators into a comprehensive mix of programs with long-term strategic objectives and implementation strategies. The program administrators have been meeting to discuss their respective groundwater protection activities in ad hoc committees for some time. Numerous meetings have occurred within and among the agencies. Indeed, the problem has not been inadequate meetings, but rather knowing which of the various committees were the ones with actual mandates and authority.

In a report by the Government Accounting Office, U.S. Department of

Agriculture: Interim Report on Ways to Enhance Management, it was observed that:

> ...task forces were good at raising policy issues, but that agencies proceed with implementation on the basis of their own interpretation of the policy discussions. Currently, each agency conducts water quality activities and functions independently of USDA's objective...Integration is left to the individual agencies and, in turn, to their individual managers. A task force advisor described USDA's implementation approach for water quality as an orchestra that is playing without a conductor, suggesting that some formal coordination or focal point was needed. The former chairperson also suggested that an institutional mechanism for implementing cross-cutting, multiagency programs, such a water quality, was needed (USGAO, 1989).

The GAO study cites the difficulties that arise when an agency attempts to integrate the programs of its own offices. The problems can be much greater when trying to integrate the programs of distinct agencies.

The 'Technical Integration Group' (TIG) appears to be emerging as a key coordinating group. Initiated by USGS, it has been supported by the groundwater coordinated activities underway at USDA/Agriculture Research Service. The integration of these two groups has now drawn in a number of additional office and agency representatives, including USEPA, TVA, and USDA/Cooperative State Research Service, Cooperative Extension System, and State Agriculture Experiment Stations. The TIG is a working example of the creation of the "Excellence Network" that was discussed earlier. At this stage, they have developed their focus groups, and are developing their individual components.

The TIG serves as a mechanism for integrating the Midwest and Mid-Continent Initiative of USGS and USDA. The Water Quality 2000 group supported by USEPA also is developing along the lines of "Excellence Network." The 2000 group appeared mired in arguments over protocol during their first year, but they are now moving at a much greater pace. Focus groups have been formed and these groups have created draft documents. The purpose of the 2000 group is to develop consensus among many interest groups. The TIG group is more involved in the development and implementation of programs.

The participants of the TIG are now facing the problems that was earlier suggested as a problem for the hypothetical MAG group. The program scientists and administrators are beginning to reach consensus on the integration of their respective programs, but they are struggling with how to make the actual integration work when they go back to their home agencies. USGS has a greater capacity to wait on allocating its funds until a comprehensive and integrated program is worked out. Other agencies and offices feel compelled to begin delivering "products" as quickly as possible, particularly ARS, CSRS and ES (Volk, 1989). At a recent TIG meeting, SCS representative were questioned regarding the protocol used to select their 37 hydrologic units. The SCS officials explained that they were operating under a separate mandate and that they had to move on a distinct timetable. They explained that in the coming year, they will be selecting an additional 37 sites, and when these occurred within the defined region of the Midwest initiative, they would try to coordinate with the objectives of the initiative, but again, they had distinct mandates that would come first. During this meeting, the TIG struggled to develop an understanding of their respective funding mechanisms and time tables, so that they could begin to plan a more integrated approach. The problem is not so much the integration of the research or education programs, rather, the difficulty will be in the integration of their distinct administrative and budget structures.

3. PROGRAM TRACKING

> Numerous methods have been developed by farmer experimentation, university research, agricultural chemical industry and consultant research and USDA. But there is no exhaustive inventory of these systems and practices, and they have not been examined to determine which ones, under various climatic, geographical, soil and hydrogeological settings, are workable or preferable and generally economical (Bird, 1989).

In the early stages of developing the TIG, USGS personnel repeatedly asked if there was any way to get a handle on who was doing relevant research in each of the State universities. It was relatively easy for them to deal with ARS, given its top-down structure. The *confederacy* of State Agricultural Experiment Station and university programs were more difficult for them to keep track off. Indeed, there is no centralized authority or clearinghouse to explain university research projects on groundwater quality. As described earlier, most of the funding to these programs comes from State and other outside sources, the Federal contribution is usually a third or less. As USGS learned, there are committees of appropriate researchers, usually organized through the Experiment Station Committee on Organization and Policy, or through the regional committee structures used by the universities.

Difficulties in keeping track of ongoing programs can sometimes take on comic dimensions. Two years ago NASA and USEPA had work well underway on a joint-project to develop some models on global change. The agricultural components of the model had been developed. Some of the NASA staff became increasingly anxious that no agricultural researchers had been incorporated in the planning or development process, and sent one of their members to an agricultural research meeting to find appropriate scientists. It is not that there were no scientists working on issues relevant to global change. There are many. The problem was that most of the relevant research that was underway was not labeled as *global climate work.* The titles of appropriate projects were much more specific than *global climate*, but people outside of the specialty areas of study would not recognize that issues pertinent to global climate were being addressed. The administrators of this particular modelling project found that agricultural scientists were working on many critical issues pertinent to a global change model, including the effects of carbon dioxide enrichment and emissions of methane and nitrous oxides. USEPA then convened a workshop and invited a number of agriculturalists to review their model. Considerable alarm developed among some of the agriculturalists as they reviewed the assumptions that had been made and the studies that were used to develop the model. Revisions to the report being developed by the USEPA group followed. It was not a matter of indifference or hostility on the part of USEPA or NASA, they simply did not know how to identify the appropriate programs or scientists.

Being able to identify which programs are underway and where seems a relatively easy task, but it is not one that all agency offices can do well. The problems typical of each of the agencies were addressed the recent assessment of USDA by GAO:

> USDA investments in information technology have improved many aspects of program operations, but USDA still lacks essential information for agency program management and strategic decision-making. For example, we recently reported that FmHA cannot evaluate its loan graduation process because it does not know how many borrowers left the program for other sources of credit. Additionally, poor interagency coordination has resulted in USDA's large data resources not being developed into an asset that can be maximized across program and agency lines. This situation exists mainly because USDA agencies are independent and parochial regarding ownership of information resources, cannot agree on common data definitions, and continue to operate under policies and procedures that do not recognize changing USDA missions. Therefore, information is underutilized by others in identifying problems, analyzing trends, and assessing cross-cutting issues important to agency missions. Because USDA plans to spend about $4 billion in information technology over the next several years, it is important that efforts are made to ensure wise use of these funds (USGAO, 1989).

Some of the agency offices do have data base systems for keeping track of ongoing efforts. On example is the Current Research Information System (CRIS), within USDA/CSRS, which tracks ongoing agricultural research. The CRIS system, however, tends to categorize programs on the basis of commodities. For a number of years, the primary concern of the agricultural community has been production of an abundant and inexpensive food supply. It is therefore not surprising that this accounting system emphasizes commodities. The system has been expanded to monitor some broadly defined natural resource and environmental issues, but it has not really been developed to categorize projects on the basis of their contribution to groundwater quality protection and similar issues. The CRIS system provides a *first cut* at isolating potentially relevant projects, but then these potential projects have to be individually evaluated. Substantial individual interpretation may be involved. Another computer data base for tracking programs exists within USDA Extension Service, they too are struggling with classification problems. An evaluation of one USDA/ES reporting systems--the Program Document Data Base (PDDB)-- suggested that

> A more precise reporting format should be provided to identify specific data that reflect facets of each program...PDDB were not consistent in their information content, their degree of specificity, or their terminology...a more consistent and precise reporting framework can promote more efficient coordination toward established national priorities (North Carolina Extension Service, 1986).

The problems referred to in this analysis are typical. Again, there needs to be an agreed upon classification system, and then development of program tracking data bases that make it possible to keep track of who is doing what, and where.

4. ACCOUNTING

Similarly, it would seem that the federal agency offices would be able to account for how much money they are spending on programs relevant to groundwater protection programs. For reference purposes, OTA staff contacted each of the Federal agency offices that might have groundwater protection activities underway. It was thought that each of the offices would be able to specify how much they were spending, and how many personnel were assigned to groundwater protection activities. Despite the fact that the offices were responding to similar requests from OMB and from the FCCSET committees, this turned out to be a very difficult task for a number of the offices. The results of this inquiry are being compiled in an separate report by OTA staff. The point here is that it was difficult for many of the offices to identify or agree on how much money they were spending or how many people they had working in the area of groundwater protection. The problems typical of each of the agencies were addressed in the GAO report:

> The Department's accounting systems are not providing complete and accurate financial information on the results of programs and

> administrative operations. Further, long-standing weaknesses in major systems place the Department at substantial risk of fraud and abuse. GAO and the USDA Inspector General have frequently reported on weaknesses in agency financial systems. Managers generally acknowledge these problems in their financial management and accounting systems, but efforts to correct them are difficult. Making system changes is often time-consuming (USGAO, 1989).

In the early stages of the OTA staff assessment, numbers were provided that suggested that the Office of Pesticides and Toxic Substances spent no money on programs relevant to groundwater quality in most years. On reflection, it does not seem likely that the Office of Pesticides and Toxic Substances was not doing anything relevant to the protection of groundwater. However, if a very tight definition of a groundwater protection program is used, they were probably right in their conservative assessment. On the other extreme, numbers were provided that showed that Farmers Home Administration was investing a large amount of funding for programs relevant to groundwater protection. Given relatively huge funding for FmHA operations, defining even a small percentage of their program as being pertinent to groundwater protection generates numbers that dwarf program efforts in other offices and agencies. While FmHA programs may be relevant to groundwater protection in a fairly broad context, it is dubious that a huge amount of money was directed specifically to groundwater protection programs.

A more refined classification system will have to be developed. It will not be possible to adequately monitor and assess the relative activities and expenditures of the respective agency programs, until they reach some manner of agreement regarding the classification of their programs.

D. PROGRAM RESOURCES

1. STAFF TRAINING

In a report by the Extension Committee on Organization and Policy, Groundwater Education: A Challenge for the Cooperative Extension System, it was stated that "major gaps in Extension's ability to conduct groundwater education programs include the conventional problems of personnel limitations and the need for staff training" (ECOP, 1985). The most severe limitations on education and extension programs are inadequate funding, inadequate numbers of personnel, and inadequate resources to train and prepare current personnel. In interview and meetings on water quality held by the Environment and Energy Studies Institute,

> The Institute learned from numerous sources that field personnel do not now understand the problems and solutions well enough to help farmers. Providing technical assistance will require staff to have both the basic facts and the understanding to interpret them to help farmers tailor practices to their site specific needs. Thus , the entire effort can fail if field staff are not well trained (Bird, 1989).

In fact, there are a number of excellent groundwater protection programs underway in a number of the States. There have been insufficient resources, however, to develop a number of national programs to supplement and integrate these State programs. The Pesticide Applicator Training (PAT) program mentioned earlier, is an example of the problems that develop when clear national guidelines are not developed to integrate diverse State activities. There are a number of programs that could be developed:

> There is no national program to provide application recommendations for reduced input management systems. Current pesticide education programs focus on restricted use pesticides, there is no national program to address general purpose pesticides, which makes up the bulk of the farm and garden use of agricultural chemicals. While some individual States have vigorous water well testing programs, resources have not been available for a national campaign to educate farmers and rural residents regarding the importance of water well testing. With a declining contribution by the Federal government to Extension programs over the past decade, States have had to struggle to make up the difference when they could (Nipp, 1989).

The Extension Service and Soil Conservation agents operating at the county level have many responsibilities besides groundwater protection. It is difficult for them to allocate the time and resources to attend groundwater training programs, particularly if the issue is not a high priority for the members of their particular county. The simple fact is that these the majority of the funds available to these agents is from their county and State governments. They have to respond to the priorities of their employers. If the Federal government wants a larger role in directing the priorities of these systems, they will have to be prepared to share a larger part of the funding burden.

Apart from training field personnel, the training of program managers is usually overlooked altogether. Somehow, program managers are supposed to be experts on the science and administrative tools that will be necessary each time they are assigned to cover a new set of issues. When the OTA staff contacted the many offices involved in groundwater programs, some office staff appeared confused as to why their administrators has claimed that groundwater was relevant to their office. In one case, FDA staff were contacted, who adamantly insisted that there was no possible connection between their operations and groundwater protection. FDA, in fact, will have to play a critical role if some groundwater protection issues are to be resolved. For example, FDA sets tolerance levels for the number of pest parts that can be found in a shipment of grain. FDA also sets limits on the cosmetic blemishes that are allowed on certain fruits and vegetables. If farmers reduce the use of certain pesticides in order to prevent groundwater contamination, then cosmetic damage to crops will probably increase. It may be possible to educate the public to accept fruits and vegetables that are not so cosmetically perfect, but FDA will have to allow the process to occur. Staff will have to be trained to recognize the broader domain of issues within which they operate.

2. FUNDING AND PERSONNEL RESOURCES

It sounds too much like agency-approved apologetics to suggest that these problems will not be addressed without new funding, but funding is a real-world problem that has to be faced. Protecting groundwater resources is going to be expensive. As suggested earlier, it will be immensely more expensive to clean up aquifers after they are contaminated, than it will be to prevent contamination in the first place. Some argue that groundwater contamination problems are over-rated, that most of the current detections of contamination reflect levels that are so low that there are no real health risks. Hopefully they are right. However, the idea is to act before contamination becomes threatening, rather than afterwards. There is also a time-lag factor. Depending on the compound, agricultural chemicals move through the environment at different rates. In some cases, low levels of detection may simply represent the forward edge of a contamination pulse that is working its way through the soil profile (Jury, 1988). Without expanded research efforts on the fate and transport of these chemicals, we will not know if these low levels indicate that there is nothing to worry about, or that the worst is just now coming. Since the cost of remediation will be staggering, it is wise to invest in prevention.

Even if prevention is relatively inexpensive compared to cleanup, prevention will not be cheap. A comprehensive set of groundwater protection programs will cost not cost millions of dollars, not tens of millions, but hundreds of millions. At some point, Congress is going to have to come to grips with the magnitude of the problem that it is trying to address. Some Congressional staff have asked why new funding was necessary for water quality protection research and education in fiscal year 1990, when several million dollars in funding was allocated in fiscal year 1989. The question reveals that the staffers did not have a working knowledge of what the total investment in water quality protection funding would need to be. Moreover, it reveals that they did not understand that water quality protection is not a product that can be bought, like a car, after which new products can be bought. Groundwater protection will be an ongoing process, it will require the development of a number of products, and the process have to be sustained over a number of years.

Water quality research alone is very expensive. Groundwater protection research is especially expensive. In testimony provided to Senator Fowler, the following conservative example was provided:

> To study the movement of agricultural chemicals through the soil profile into the groundwater usually requires drilling wells for sampling, which may cost several thousand dollars apiece. To process and analyze a water sample for agricultural contaminants following EPA protocols will cost several hundred dollars. Each well site will require a number of samples to follow fluctuation and movement of the chemicals over time. To get a rough feeling for the costs, let us suppose that one sample is taken from a well every two weeks over the course of a year. Analyzing these samples will cost over $7,000 to $8,000. Imagine that 10 sampling sites are chosen, which is a very small number, then $70,000 to $80,000 a year will

> would be spent on sampling costs alone, not to mention $20,000 to $30,000 in drilling costs, not to mention labor and other costs. This example portrays the costs of one fairly small monitoring study (Nipp, 1989).

Where is new funding for these expensive programs going to come from? Program administrators naturally prefer new funds to implement new programs. Congressional staff wonder why old programs can't be faded out and funds redirected to new concerns. Administrators respond that they have been redirecting funds, and that there are no more funds to redirect. It is a difficult issue. Congressional members and staff can look at a list of programs and can come up with a number of programs that could be cut. The problem is that the programs that are seen as being a waste in one Congressional office are seen as essential in the adjacent Congressional office. It is just as difficult in agencies, offices and university departments across the country. One person's *pork* is another person's *lifeblood.* When relative worth is difficult to ascertain on scientific and technical grounds, decisions will certainly be made on political grounds. Congress and the agencies will continue to struggle over funding allocations.

In the case of groundwater protection, however, redirection is something of a moot point if Congress wants to develop a national program for water quality protection. The States are already investing many times the Federal investment in each State. The States are going to determine their respective agendas and priorities, unless the Federal agencies are provided with resources to deliver. However, an investment in new funding by the Federal agencies can be used to leverage a larger investment by the States. Many of the groundwater research and education programs developed in the Water Quality Initiative have *matching* requirements, where State or local governments much match the Federal funding to receive funds. Resources are scarce enough, that States are willing to comply with Federal guidelines in order to secure new dollars. Moreover, there is widespread readiness in the States to respond to Federal dollars. For example, in fiscal year 1989, after discounting Congressionally *targeted* projects, CSRS received about $1.8 million in new funds for groundwater research to be carried out across the nation. Approximately 238 research proposals were submitted, of which only about 20 could be funded (Volk, 1989). More that a hundred proposals of the remaining proposals were of high quality and would have been funded, had funds been available. State researchers and educators have programs in the waiting, but the Federal government will have to decide to come up with sufficient funding to get these programs launched, and to invest sufficient resources to leverage the coordination of the diverse State programs into an integrated national program.

E. PROGRAM IMPLEMENTATION

There are things worse than failing to coordinate or integrate agency groundwater programs, and one is failing to address a critical issue altogether. Such failures can result when the problem issue lies between the authority of different agencies. It may be that no one wants to tackle the problem. It is often the case that no one can get funding to address the issue. And, it is sometimes simply that no one recognized the problem. Sometimes everyone recognized the problem, but so much energy gets spent in identifying which agency has authority to act that no one acts at all. Some examples of some program areas that need special attention follow.

1. SAMPLING TECHNOLOGIES

In a National Research Council study, Pesticides and Groundwater Quality (Holden, 1986), it is stated that

> Some 200 pesticides are in common use, and a wide range of hydrogeologic conditions affect the susceptibility of groundwaters to contamination. Clearly it is impracticable to sample every aquifer and test for every pesticide. Rather, efficient monitoring of resources depends on the establishment of systematic procedures for sampling and testing and the collection of data that can be used to identify critical site/pesticide combinations.

At present, one of the *rate-limiting* steps in groundwater monitoring and research is the cost of processing soil and water samples. It is relatively inexpensive to test well-water for nitrogen contamination, but pesticide residue analysis may cost hundreds of dollars each and may require expensive equipment. The development of new sampling technologies needs to be accelerated. As the costs of processing individual samples goes down, the more samples can be taken and the better monitoring and research program can be developed. There is some hope in the area of immuno-bioassays. Very inexpensive bioassay tests for several pesticides have been developed. These tests can be very simple, very quick, safe and conducted with little to no training. The problem with bioassay tests is that they are very specific, they may only detect one metabolite out of a broad range of compounds that a pesticide is transformed into. In some cases, however, equilibrium-analyses could be developed for a range of pH and temperature conditions so that the detected metabolite could be used to indicate the relative presence of the alternative forms of the pesticide. In any case, bioassays could be used as a screening tool, to detect areas of possible contamination, to indicate where more expensive testing should occur.

In addition to developing new tools, there needs to be interagency agreements on sampling protocol, standards, and research methodologies that are available. Scientists studying groundwater contamination problems will look at different components of the total array of problems. The problem that they select will determine in some measure the analytical tools and procedures that they use. However, for any given area of study, there are usually a number of analytical tools that can be chosen. Returning to the nitrogen example, a number of different laboratory tools can be used to analyze soil sample for nitrogen content.

The choice of laboratory tools will introduce a certain mix of assumptions and caveats that will influence how the data from the research is to be interpreted. If separate research projects use different technical protocols, it may be impossible to compare their results with any degree of certainty. On one hand, researchers may need to choose particular tools to solve the specific problem they are studying. On the other hand, it makes sense to establish agreed upon protocols where possible so that the net result of hundreds of studies will be comparable and add to an accumulated body of knowledge about groundwater contamination. If there is a lack of such protocols, before studies are conducted, it may be impossible to integrate their results or extrapolate their findings.

Attempts have been made by each of the agencies to address this issue, and progress has been made. However, the problem remains. Congress may wish to insist on a speedy resolution.

2. DATA COLLECTION AND MONITORING

A lack of historical pesticide use data has hindered identification of potential contamination problems. Furthermore, current pesticide use data are seldom adequate (they are either incomplete or too aggregated) to identify specific areas of high risk. The absence of up-to-date and accurate pesticide use data is particularly troublesome in susceptible regions where pesticides may be newly introduced to replace products restricted because of previous groundwater contamination (Holden, 1986).

Congressional staff and interest groups are often frustrated by the agencies inabilities to answer some of the simplest of questions. Fundamental questions relevant to groundwater protection include how much of each agrichemical is being used, where, and under what conditions? The problem is that none of the agencies are charged with keeping this kind of information. USDA/ERS once maintained a data base on pesticide use across the country, but gave it up as being too costly. Resources for the Future acquired the ERS data base, and have been maintaining as best as their resources have allowed. ERS has recently received funding to begin tracking pesticide use again, but their resources only allow them to develop some prototype survey programs. USEPA has picked up a data base from TVA that records nitrogen fertilizer use for every county.

It would seem that keeping track of pesticide and fertilizer use would be a straight forward task, but it is not. Many farmers and farm groups have resisted mandatory record keeping for fear of the paperwork and resistance to the intrusion in their privacy. Some have noted, however, that farmers will have to begin keeping such records in self-defense (Stiles, 1989). If laws allowing citizens to file suit against groundwater contaminators spread beyond California and Connecticut, farmers will need to have records to prove that they were not responsible for contamination that occurs.

In the absence of detailed records on agrichemical use, fairly complex extrapolations are made from sales data and surveys. If rational programs are going to be developed, more effort will have to be invested in the development of pesticide and fertilizer use data bases. Policy-makers and program managers simply must be able to answer simple questions about how much of each chemical is being used, where, and under what conditions, or the policies that they develop be inevitably be too broad and generic.

3. DATA BASE DEVELOPMENT AND INFORMATION MANAGEMENT

A tremendous amount of groundwater data is being collected by the Environmental Protection Agency, the Department of Agriculture and the United States Geological Survey, not to mention the data being collected in each of the States. Unfortunately, the many data bases that have been created are rarely compatible and there has been little agreement on a standard set of measurements to be incorporated in all studies. Continuing with the nitrogen analysis example, when measuring the availability of nitrogen in the soil for plant growth, a number of different laboratory techniques can be used to process soil samples. A particular laboratory technique may be more appropriate for a clay soil in a particular region of the country than it would be for a sandy soil from another region. Scientists have designed different tests to get particular kinds of information, and they make sets of conditioned assumptions when they interpret the results of such tests. It is normal for the research and sampling protocols to be recorded when the researchers publish their results, but this qualifying information is not always included in agency data bases. USEPA has engaged in a substantial study just to try and characterize the quality and nature of the data in some of their data bases. Without access to information on the ways data was acquired, much of the available information may be useless. The agencies need to agree to a minimum set of data records for storing and retrieving groundwater data, as proposed by USEPA (USEPA/OGWP, 1988).

4. RESEARCH

> Even the briefest of inquiries will reveal a clear and compelling documentation of the need for more basic research, more data collection, more programs which put the results of research and the tools for using information in the hands of decision-makers (Smith, 1989).

There are myriad research questions that need to be addressed. A list of important research topics is provided in the Experiment Station Committee on Organization and Policy, Groundwater Quality and Management (ESCOP, 1985). Additional research needs are identified in Appendix 9. As discussed in the section on resources, the research community is poised and ready to increase their research efforts on a broad array of issues, as quickly as funding becomes available. In exchange for increased funding, however, the research community is going to have to develop the capacity to better explain to Congress how groundwater research topics are selected and funded.

- Prioritizing problems

There have been many attempts to develop mechanisms to coordinate and prioritize research programs. USEPA has a science advisory panel. USDA has the Joint Council for Food and Agricultural Sciences and the User's Advisory Board. The Experiment Stations Committee on Organization and Planning has a yearly prioritizing process and a five year plan. The Extension Service Committee on Organization and Policy has identified nine national priority areas. This does not begin to include the many management offices and coordinating and planning committees within these agencies, as well as those in TVA and USGS. In addition, there is the Office of Management and Budget, which is trying to coordinate all of the Federal Agency programs. OMB has shown particular interest in the areas of water quality and global change. There is also the Office of Science and Technology Process (OSTP) in the White House, and the Federal Coordinating Council on Science, Engineering and Technology (FCCSET). The Committee on Earth Science (CES) of FCCSET has been active in the development of reports on federal agency activities to protect water quality and the global environment. A discussion of the roles and responsibilities of these various organization is discussed in Appendix 4.

Despite all of this planning and coordinating activity, there are still a number of bills being introduced in Congress to facilitate and mandate the development of coordinated and integrated groundwater protection programs. A cursory review of the more than 3 dozen water quality protection bills introduced in the 100th Congress will quickly lead to the conclusion that Congress is convinced that the federal agencies have not yet developed the mechanisms to coordinate their programs or to prioritize which programs need to be done first. It is relatively easy, for example, to come up with a *laundry list* of all of the things that could or should be done to study the fate and transport of agrichemicals in the environment. It is usually more administratively difficult to come up with criteria for selecting one type of fate and transport project over another.

Each of the agencies have come up with rough categories of research projects that need to be addressed, but these categories are usually fairly broadly defined and the *logic* underlying the selection of these topics, or the criteria that will be used for selecting projects within the selected topics, is rarely if ever defined. For example, out of a list of possible projects, is there a *temporal* logic? Do some projects have to be done before others can be done? In the case of groundwater sampling, have cost-effective sampling tools and technologies been developed? Could inexpensive sampling technology be developed with a minimal initial development? If effective sampling technologies need to be developed, and they can be, it would be logical to *front-load* financial resources into the development of these tools before engaging in wide spread sampling programs. Similarly, is the relevant *magnitude of impact* considered? If 80% of all pesticide contamination of groundwater is suspected to occur in areas with sandy soils, shallow groundwater tables, high precipitation, and heavy corn production, it would make sense to direct most of the available funding to this highest risk and highest impact area, rather than dilute the available money over a broader range of interesting but less critical projects.

Scientists and program administrators have been struggling to develop rationally constructed research plans. The recent efforts by the 'Technical Integration Group', the USEPA sponsored Water Quality 2000 project, the USGS Midcontinent Initiative and the USDA Water Quality Program to Support the President's Water Quality Initiative demonstrate remarkable progress in this direction. But again, the decision-making rules are not explicitly explained. Moreover, little progress has yet been made in defining decision-making rules to prioritize jointly conducted projects, or to jointly define the order in which each of the agencies should conduct their individual projects so that the results of the programs are available to the other agencies in the most beneficial time-frame.

- **'Systems' problems**

Part of the difficulty in prioritizing the groundwater research agenda is that diverse disciplines must be integrated to study the interactions of the agricultural and hydrologic systems.

> A systems approach to research is essential to the progress of alternative agriculture. Agricultural researchers have made important contributions to many components of alternative as well as conventional agricultural systems. These contributions include the development of high-yielding pest resistant cultivars, soil testing methods, conservation tillage, other soil and water conservation practices, and IPM programs. Little recent research, however, has been directed toward many on-farm interactions integral to alternative agriculture, such as the relationship among crop rotations, tillage methods, pest control and nutrient cycling (NRC, 1989a).

It is relatively easy for scientists within a discipline to establish priorities within their areas of specialty. It is more difficult for scientists to rank the importance of their respective disciplines. It is difficult to be objective. Interdisciplinary and interagency committees will have to develop a comprehensive long-term strategy for groundwater research first, then develop decision-making rules to determine which projects are supported, and then develop the mechanisms to make sure that the results of the many individual efforts are integrated into real-world solutions to groundwater problems.

- Political problems

Some have drolly commented that prioritizing and coordination problems are a natural consequence of the way in which funds are appropriated in Congress, with more Congressional concern over the location of programs in home districts and States than in what the programs will actually do (none of these political *wags* wished to be quoted, which also means something). It seems logical to assume, however, that the funding process will always be a highly politicized process, and that the scientific and education communities are not to be excused from coming up with logical, well defined, well integrated national programs.

Once technically adept programs are designed, scientists will have to work with their political counterparts to package the programs in ways that are politically palatable. A strong effort will have to be made to insure that well-designed programs survive the political process, but scientists need to be actively involved in supporting programs through the political process. The support and development of programs, by those who best understand the programs, is a cornerstone of participatory democracy. Some of the scientific community will choose to abstain from the process. Many scientific groups will seek funding for their particular projects, without regard for the development of national programs. However, if the scientific community defaults on its initial responsibilities to develop comprehensive and integrated national groundwater protection programs, and then chooses not to participate in the political process of securing support for these programs, then the scientific community will have no basis for complaining that the programs that are developed are poorly constructed. Congress is the meeting place of ideas and the brokerage house of power.

Congress should not be held accountable for not possessing technical and scientific skills that scientist do. There needs to be a new level of involvement by scientists and educators in the development of groundwater legislation, policy, programs, planning, and prioritizing. As argued by John Kenneth Galbraith, in The New Industrial State:

> In a scientifically exacting world scientists must assume responsibility for the consequences of science and technology...The individual member of the educational and scientific estate may wish to avoid responsibility; but he cannot justify it by the claim of higher commitment (Galbraith, 1973).

5. TECHNOLOGY TRANSFER AND EDUCATION

> Innovative farmers have developed many alternative farming methods and systems. These systems consist of a wide variety of integrated practices and methods suited to the specific needs, limitations, resource bases, and economic conditions of different farms. To make wider adoption possible, however, farmers need to receive information and technical assistance in developing new management skills (NRC, 1989a).

As discussed in the previous section on training, many of the States have high quality education and technology transfer programs underway. However, the national agencies have lacked the resources and the mandates to develop national programs to integrate these good efforts, or to assure that programs are being developed in each of the States. A number of important issue areas are not being addressed.

> There is no national program to provide application recommendations for reduced input management systems. Current pesticide education programs focus on restricted use pesticides, there is no national

> program to address general purpose pesticides, which makes up the bulk of the farm and garden use of agricultural chemicals. While some individual States have vigorous water well testing programs, resources have not been available for a national campaign to educate farmers and rural residents regarding the importance of water well testing. With a declining contribution by the Federal government to Extension programs over the past decade, States have had to struggle to make up the difference when they could (Nipp, 1989).

It is widely recognized that fertilizer and chemical dealers have a great impact on farmer decision-making. A number of surveys have shown that farmers depend on dealers for recommendations on the choice, rates, timing and application tools for their agricultural chemicals (Agricultural Law and Policy Institute, 1986, American Farmland Trust, 1990). In these surveys, farmers usually rate the Extension Service and university researchers higher regarding quality of information and lack of bias, but they simply are not as accessible as the dealers. While the dealers have a clear vested interest in promoting high use of agricultural chemicals, a growing number of dealers recognize that they are going to have to provide information and management services as well as their products, so that farmers can produce within environmentally safe boundaries. Some companies, such as CENEX-Land O' Lakes, are capitalizing on the need for environmental management information. In this environment, there is a need to develop national education programs to train agricultural dealers. There are no such programs at this time (Hauck, 1989).

A specific example of the need to develop consistent national guidelines for

State programs is in the area of agrichemical *back flushing* from *chemigation*, which is the process of injecting agricultural chemicals into irrigation waters. This can be efficient and even more environmentally benign than some practices. However, is important to include devices that will prevent contaminated water from being pumped back into the wells if there are problems with the machinery. Such a mechanical problem could result in the effective equivalent of placing a hose in a well and injecting agricultural chemicals into the well. This problem can also develop when filling pesticide applicator tanks with water. The devices to prevent this kind of *back flushing* already exist. However, only a few states have regulations to require that these devices are used (Davidson, 1989).

F. CONTRADICTORY PROGRAMS

Even if adequate and well coordinated research, education,and regulatory programs are developed to protect groundwater from contamination by agricultural production, there is concern that these efforts could be overwhelmed by conflicting federal programs that indirectly promote inappropriate use of fertilizers and agrichemicals. As argued in the recent report by the National Academy of Sciences, Alternative Agriculture (NRC, 1989a):

> A wide range of federal policies, including commodity programs, trade policy, research and extension programs, food grading, and cosmetic standards, significantly influence farmers' choices of agricultural practices. As a whole, federal policies work against environmentally benign practices and the adoption of alternative agricultural systems, particularly those involving crop rotations,

> certain soil conservation practices, reductions in pesticide use, and increased use of biological and cultural means of pest control. These policies have generally made a plentiful food supply a higher priority than protection of the resource base.

There are special concerns regarding the impact of Federal farm programs on groundwater protection. As explained by Judy Campbell Bird, of the Environmental and Energy Studies Institute:

> Throughout our investigations, farmers across the country told us that groundwater contamination by agricultural chemicals is rooted in U.S. farm policies and programs over the last 20 years. These policies, tying payments to production of specific commodity crops year after year, led farmers to chose continuous cropping patterns and to maximize their yields through intensive pesticide and chemical use....Interestingly, farmers told us they did not want to be so dependent on chemicals. They wanted to avoid the costs of purchased inputs. They worried about the safety of their drinking water. They were frustrated that they, the stewards of the land, were creating natural resource problems. They said they were willing to adopt new farming practices and management systems, but thy just didn't know how, especially when federal subsidy programs often prevent them from doing so economically (Bird, 1989).

The effect of federal subsidy programs on water quality was discussed at a conference of the National Governor's Association. They observed that

> ...federal price support programs contain several incentives for heavy use of chemicals. One incentive is that eligibility for price supports is based on enrolled acreage, which encourages farmers to maximize production from these acres. Several changes in these programs could counteract these incentives, including expansion of the Conservation Reserve Program to include lands with severe water quality problems and expanding cross- compliance to include best management practices for chemicals (National Governors Association, 1989).

Mechanisms will have to be developed among the agencies and their respective offices, to ensure that groundwater protection programs are not overwhelmed by other agency programs.

G. FAILURE TO SEE 'THE BIG PICTURE'

Agricultural production has evolved a complex infrastructure to support the delivery of agricultural *inputs* and to process and deliver agricultural products to consumers. The entire food production system has to be considered when developing programs to protect consumers from harmful exposure to agricultural chemicals.

> Groundwater protection needs associated with the complete process of manufacturing, formulating, transporting, delivery, and applying agricultural pesticides should be assessed, and appropriate management standards developed where necessary (Holden, 1986).

Moreover, public concerns about groundwater quality are a part of a larger domain of concerns. The public and Congress are also anxious about surface water pollution, atmospheric pollution, food safety, and global climate change. These are inseparable issues. The chemicals that a farmer applies to a field may leach through the soil profile and into the groundwater; they may bind to soil particles and run off into streams, lakes and oceans; they may volatilize and move into the atmosphere; or they may stay with the plant product as a residue that is hazardous to human consumption. This is not to say that application of every agricultural chemical is an environmental disaster. Rather, that the use of such chemicals touches a broad array of inseparable public concerns and must be addressed accordingly.

While it may be impractical to deal with all environmental issues at once, going to the other extreme and dealing just with groundwater out of the context of the surrounding environment may lead to inappropriate actions. As discussed, soil conservation plans developed to prevent soil erosion may unintentionally cause an increased infiltration of contaminants into groundwater. In this situation, decisions will have to be made regarding which of the two problems poses the greatest environmental threat, and management practices will have to be developed on the basis of the soil types, depth to the groundwater, leaching, and chemical properties of the agrichemicals and climatic factors. The point is that it is necessary to consider the entire hydrologic cycle when specific groundwater problems are considered. Laws that address only a fragment of the hydrologic cycle will fail to completely address problems that exist and may inadvertently create new problems.

III. SOME SOLUTIONS

It is important to realize, when
discussed, that it appears that agency a
to put together well-integrated, compre
They too, are struggling to find ways t
programs, to find ways of coordinati
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lize, when considering the difficulties that have been it agency administrators and program managers want ted, comprehensive groundwater protection programs. find ways to adequately support ongoing and proposed coordinating with other agencies, and to overcome blocks. This willingness is an important and decisive legislation. Mandating programs on unwilling and rs often results in programs that do not get developed d. Authorizing legislation may mean little if not s, but even with appropriations the legislation may abotaged by unsympathetic administrators. The kind to deal with a recalcitrant administration might in legislation designed to provide the Federal agencies d resources with which to go forward.

water protection, there is a unique opportunity for all orward together, including interest groups, Congress, on. It is just a matter of figuring out how to move: in fact be the critical issue, there are numerous efforts

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and programs, but the struggle remains over how to put all the pieces together. During the preceding discussion on problem areas, some specific *solutions* have been suggested. In the discussion that follows on additional solutions, the intent is to address *large scale issues*, while expanding on some of the more critical options.

A. Some Questionable Options

For the sake of completeness, a few options are provided that are not recommended. They are provided too, in order to provide some contrast with the options that will follow and because these options are in fact often selected, if only by default.

1. Do Nothing

One of the most frequently overlooked options in policy analysis reports such as this, but often the alternative that is implemented, is the option of nothing at all. If nothing is broken, why fix it? In the case of groundwater protection, the federal agencies have begun to address the issues. Whether the Federal agencies have responded to perceived public concerns, or acted in response to rumblings within Congress, or they've *smelled* new funding opportunities, or they're responding to Office of Management and Budget fiat, the agencies have achieved a surprising level of coordination and collaborative planning to address groundwater contamination issue. There has been some provinciality and some squabbling over territory, as would be expected. What is surprising is that there has been so little dispute and that a fairly congenial atmosphere of cooperation has developed...at least so far. Since agencies are moving down the road, one option is simply to wave them on and hope for the best. The question, however, is whether the agencies will be able to maintain this momentum without continued evidence from Congress that groundwater protection is a high priority concern, given the many areas of concern that must be addressed by the agencies. Moreover, the agencies may need help in resolving any disputes over their respective authorities and mandates, without some guidance from Congress.

While Federal administrators would probably appreciate a Congressional *pat on the head*, most would be quite unhappy if the *pat* was accompanied with instruction to go forward and do more good work without the provision of new resources. Congress, on the other hand, is likely to resist providing sustained increases in funding without the sense that the previously discussed problems are being addressed. The USDA Water Quality Plan to Support the President's Water Quality Initiative is perceived as being a good step in the right direction, but some Congressional staff have suggested that it will have to be expanded, developed, and be better *packaged and delivered.* The development of an interagency package of integrated groundwater protection programs and budgets would go a long ways towards assuring Congress that integrated planning is underway.

2. BLUE-SMOKE AND MIRRORS

Sometimes, when the intent is to do nothing, there remains the need to appear to be doing something. This is referred to fondly as the old *blue-smoke and mirrors* gambit. Some may be genuinely convinced that there really is no threat to our groundwater resources, others may have reasons--vested or otherwise--to prefer to believe that there are no real threats to human health, and yet others may sincerely believe that all that needs to be done is being done. Despite this, these same individuals may feel that the general public needs the calming influence of the appearance of action. To this end, there are a number of time-honored and well-tested strategies, including:

- appointment of committees to study the issue further until public interest dissipates, it is critical to avoid giving the committees any mandate or directions on specific topics;
- appointment of a new Council, Interagency task force, or other coordinating group, carefully making sure that it lacks authority or power to implement its objectives; or,
- development of new government programs, without providing any financial resources to actually carry out their mandates.

Despite these not so subtle jabs, committees and coordinating groups can and should have an important role in the development of interagency groundwater protection programs. However, there are over 2000 commissions in Washington D.C. already. It is difficult to imagine an issue that is not already covered by its own commission. The point is that simply appointing such a group in insufficient, the authority, organization and membership of the group has to be carefully crafted and in order for them to have the capability of doing anything substantial, least Henry Cooke's maxim prove true, that they are simply "...a group of the unfit, appointed by the unwilling, to do the unnecessary" (Webster, 1988).

B. Some Fundamental Options

1. Divide and Conquer

A more substantial approach to managing groundwater protection is to break the large complex issue of groundwater protection into relatively small topical components. Specific agencies and offices can then be assigned specific responsibilities for particular components. This is the bureaucratic equivalent of the reductionist approach used in science. There is often considerable merit to this approach. It can and should be used to break otherwise unmanageably big problems down into manageable ones. In the case of groundwater protection, there are numerous topical components: fate and transport of agrichemicals in the environment, development of sampling technologies, data collection and monitoring, remediation, development of farm management practices, demonstration projects, and on and on. It is possible to look at point-source pollutants and non-point pollutants, well-head protection and septic tank management, nutrient and livestock management, farm and urban use of pesticides, and again, on and on. The problem with breaking the issue up into its many components is that at some point all of the pieces have to be put back together again into a comprehensive, coordinated, and integrated package of programs. As discussed, it is precisely that there is a lack of understanding of how the pieces interact, or an understanding of how to put the components back together, that is particularly troublesome in groundwater protection. Some sort of rational integrating system will be necessary to coordinate all the components that have already been established.

2. RESHUFFLING

A strategy closely related to *divide and conquer* is *reshuffling*. Once topical components are identified and responsibilities assigned, it might become evident that the current configurations of administrative structure place functionally insurmountable barriers between individuals or groups that need to work together to solve specific problems. One solution to this problem is to take all the people out of their respective agencies, reshuffle them, and put them together in some new office or agency so that they will have direct contact with each other.

Returning to the study of Atrazine in groundwater, there are scientists that work on the fate and transport of Atrazine housed in each of the agencies. Within a given agency, scientists might be housed in separate administrative offices. In the case of USDA alone, scientists examining Atrazine movement into groundwater could be housed as ARS, CSRS, ERS, or SCS. In the worst case scenario, these scientists may develop their programs and work completely independently. In the best case, these scientists are coordinating to develop programs that are logically integrated into a rational mix of projects. The actual case is probably somewhere in-between the two extremes for most groundwater work. A reshuffling solution to insufficient coordination between the agencies with groundwater programs might be to establish a new 'Groundwater Protection Agency', and house all the previously defined topical components within this new agency. In this case, there could be an 'Office of Atrazine Transport'.

Restructuring agencies is often an understandable reaction to a new social concern. It is a relatively concrete action, it creates a structure that can be identified and held accountable for new concerns. In some instances, where a problem is not being addressed it may be the only alternative. Creating a Groundwater Protection Agency would certainly provide for communication among appropriate scientists that are currently housed in separate agencies, but it would not resolve their continuing need to coordinate and communicate with their original home agencies. Moreover, constantly creating new agencies to deal with each new social concern will exacerbate the problem of an ever expanding government bureaucracy. Reorganizing existing agencies also dissipates a tremendous amount of organizational energy; it disrupts institutional memory and ongoing programs; it will create new organization problems and it may fail to address original complaints. This doesn't mean that it shouldn't be done at times, but that it should not be done just because it is an easy way out.

Reorganizing the Federal agencies to address groundwater concerns does not come to grips with a critical fundamental issue, which is that most contemporary social and environmental issues will require the coordination and integration of the efforts of each of the agencies. Each problem will require a different mix of agency activities. Whatever organizing principles are used, each of the agencies will have to learn how to better enable their respective units to join with their appropriate counterparts in other agencies. These units will have to have the flexibility of grouping and regrouping, based on the particular social issue. Each agency will have to develop the ability to organize in ways that cut laterally across institutional lines of authority. Ideally, agencies might be restructured so that they were made up of modules that could be assembled in varying combinations to provide an optimum aggregation of resources to address each specific social concern.

Jim Davidson, Experiment Station Director in Florida, has pointed out to his colleagues that if they were organizing their university back in 1900, knowing what they know now, that they would probably put things together very differently

(Davidson, 1989). He has requested that interdisciplinary teams be established to begin some 'what if...' thinking about optimal university organizational structure. He recognizes that change is not coming soon, but he wants people to begin speculating about what the best possible world might be like. Maybe it's time to start the same pondering about federal bureaucracies.

C. Some Critical Options

1. Establishing Goals and Standards

One option for Congress is to establish clear and specific national goals to protect groundwater resources, goals to "to protect and enhance the physical and biological integrity of the nation's groundwater resources" (Smith, 1989). At this stage, the program leaders within each of the agencies should be able to define the *working* objectives, goals and implementation schedule under which they are operating. However, they may or may not have shared this working agenda with other agencies, or even within their own agencies. Representatives of USEPA, USDA, and USGS have asserted that there was good cooperation and coordination between the agencies in the development of their groundwater programs (Hearing, 1989). Yet none of the witnesses were asked to state what the fundamental goals of their respective agencies are or what appropriate goals for each might be. Given that each of the agencies has a different institutional structure, and different sets of resources and internal expertise, it seems reasonable that they should have distinct but complementary goals.

Each of these agencies and their respective offices should have clear, specific, and measurable goals that are relevant, integrated, and coordinated towards attainment of explicitly stated national objectives. Each agency should have a published *working plan* that states how they will reach their goals and their timetable of implementation. Some agencies are already developing their own goals and implementation plans -- which is excellent -- but Congress may wish to ensure that all of the agencies take this action, that these efforts are coordinated, and that they adequately reflect the concerns of Congress and the public.

To reach such a set of goals, objectives, and timetables, Congress may wish to pursue a more interactive planning process than is normally used. Rather than mandating by *fiat*, without a sufficient understanding of current agency activities, Congress might wish to instruct the respective agencies submit *working goals*. Congress and the public could review the proposed goals before legislating the mandate for each of the agencies.

In addition to agency and program goals, many State administrators look to the Federal government to establish national standards for groundwater quality. There may be dispute whether States should be allowed to set stricter standards than the Federal government, but all look for Federal involvement and leadership. A number of program administrators have complained that it is difficult to develop programs to protect groundwater from contamination, when they don't know what level of groundwater purity they are trying to reach. Obviously, the fewer contaminants the better, but the costs of programs may be directly correlated to the level of purity that is sought. The States look to the Federal agencies, particularly USEPA, for guidance on health and toxicological standards. At present, USEPA is way behind schedule regarding the 1988 amendments of the Safe Drinking Water Act to establish national drinking water standards for 83 contaminants. USEPA has been constantly late in the development of standards and the review of agricultural chemicals. Why? Are necessary technologies not available? Does USEPA lack adequate staff or funding? Has political opposition in the past debilitated these programs? Has Congress imposed unrealistic deadlines? Congress may wish to review USEPA's implementation agenda, and determine what the obstacles have been and resolve them.

2. PROGRAM SUPPORT

It is both true and trivial to say that in order for any groundwater programs to succeed it is critical to ensure that they receive adequate funding and dedicated staff support. In an era of diminishing fiscal resources, severe decisions are going to have to be made about the public's commitment to protecting groundwater from contamination compared to other social concerns. No set of groundwater protection programs will succeed with sporadic, haphazard, and inadequate funding. The difficulties involved in USEPA's attempt to implement Section 319 requirements to develop State plans without appropriations is a case in point.

It is appropriate to demand coordinated, cost-effective, well-planned, and effectively-implemented programs. It is not reasonable to develop authorizing legislation to develop these programs, and then not work to ensure that they are funded. The better designed the programs, the more carefully coordinated the components, the more they will be damaged by erratic funding.

The National Research Council recently released a report entitled Investing in Research: A Proposal to Strengthen the Agricultural, Food, and Environment System (NRC, 1989b). Based on this report, there is an effort underway to develop support for an increase of $500 million for agricultural research. Part of the rationale of this effort is that public concerns about the effects of agricultural production on the environment have to be addressed. Water quality is explicitly identified and the need to respond to specific needs are identified:

- developing cost-effective agricultural and forest management systems that minimize or, preferably, eliminate surface and groundwater pollution from both point and nonpoint sources;
- devising land management practices that reduce or eliminate the transport of pollutants through surface and subsurface flows and assessing the quantitative effects of such practices;
- developing methods for increasing water yields and availability while minimizing water quality degradation;
- using irrigation waters more efficiently;

- designing innovative systems for restoring water quality and preventing contamination from nonpoint sources;
- developing cost-effective remediation systems; and
- understanding the economic and social effects of possible abatement, remediation, and agricultural production strategies.

Research on groundwater protection, as well as other environmental and natural resources issues, could fit into this new funding framework, should it become available.

If Congress wishes to seriously address groundwater protection problems on a national basis, it will be necessary to add up the costs and make a long term commitment, rather than fight over an inadequate investment each year. This will be easier said than done. Congress may wish to request that the agencies put together an interagency proposal to develop and implement comprehensive national groundwater protection programs. The agencies are already somewhat experienced in developing groundwater protection budgets for OMB. As well, the agencies have already developed documents that could serve as the foundation for an integrated interagency plan. In this planning document, several comprehensive groundwater protection *packages* could be proposed. Congress could then request that OMB or CBO work with the agencies to develop a long-term price tag for each of the options. Once the total *package* and its price-tag are identified, then Congress can focus on the funding mechanisms.

The suggestion of an interagency budget proposal may sound innocuous, but it is a fairly radical concept. Each of the Congressional appropriations subcommittees carefully oversees their respective domains. An integrated interagency budget proposal would require review and approval by each of these subcommittees. The agencies are somewhat familiar with putting budget proposals together for OMB, but they are not experienced in developing integrated joint-proposals. The resulting budget plan would have to be modular, so that each agency's components could be reviewed and approved by the appropriate Congressional subcommittees. This process would be different from the current situation, however, in that each of the agency modules would fit into a comprehensive funding plan. This exercise would provide agency budget administrators with needed experience in evaluating each others funding and administrative mechanisms. The exercise would also demonstrate to Congress that the agencies are coordinating their respective efforts. However, Congress will also have to make some changes. It will have to develop the capacity for intercommittee review, if it wishes to see the development of interagency programs.

Congress is sometimes faulted for being a cause of some of the problems that it wishes to see solved. For example, Congress is often faulted for mandating a program and then not funding it. The development of USEPA's 319 plans is a classic example of an agency receiving a directive from Congress, developing a program in response to their Congressional mandate, and then not receiving funding. However, Congress is not a homogenous group making these decisions in concert. There are *authorizing* committees and *appropriating* committees. There are good reasons for keeping these functions distinct. Someone has to make the hard decisions over how to allocate funds among the many worthwhile projects that are authorized. But the result of this separation of powers inflicts confusion and chaos on the management and implementation of programs. If Congress chooses to require long-term interagency groundwater management programs, it will have to develop mechanisms to provide the assurance of long-term support to implement the programs.

3. TRAINING

Some environmentalists have advocated strengthening of the Pesticide Applicator Training program. There are currently no national guidelines for the program, and the quality of the training programs can vary greatly from one state to the next. If the PAT program is going to be strengthened there must be some resolution of the respective authorities of USEPA and USDA. Congress could: (1) put the authority and appropriations for pesticide applicator training programs in USDA/ES, with adequate funding; or, (2) clearly define the respective responsibilities of the two agencies. Congress could decide to identify a number of issue areas where federal guidelines and support are needed to integrate State programs into an integrated national campaign, including national education programs to address general use pesticides, risk assessment and household use of agricultural chemicals.

In addition to establishing training programs for the public, training programs need to be developed for agency and field staffs. When field staff and program managers are assigned to a new topical area, such as groundwater, they should receive some form of orientation training, as part of there career development and as part of the offices' efforts to develop internal managerial resources. Even if staff bring expertise in one area, they will naturally be lacking in others. Problems like groundwater contamination require an understanding of the rudiments of hydrology, soil science, agronomy, economics, sociology, administration and law, just to name a few of the relevant disciplines. It is unreasonable to assume that all staff will be able to develop a sufficient working knowledge of these disciplines on their own. Issue-oriented continuing education, training seminars, and workshops should be used to develop staff capabilities to manage their groundwater projects. Such issue-oriented training should be an operating part of each of the agency's management programs. Career advancement or raises could be based on the successful completion of courses and training. Those who already have the training could test out of specific programs, to avoid wasting their time on unnecessary review and to avoid being penalized for not participating.

In the problems component of this paper, it was suggested that the agencies need to develop mechanisms to identify when agency programs were conflicting or overwhelming groundwater protection programs.

4. FACILITATING COORDINATION AND INTEGRATION

In the preceding sections some actions have been discussed that could be taken to facilitate federal agency efforts to protect groundwater. Some of the problems inherent in some of these options have been identified, but the discussion of each has reiterated that there is a clear need to develop mechanisms to insure integrated, well-developed interagency programs. It is not that the participants are unwilling to develop these programs. Rather, it appears to be more a matter of (1) not knowing how to proceed, (2) not being able to overcome the natural administrative inertia that exists, or (3) that the proponents of interagency coordinating efforts lack the authority to commit their respective institutions.

- Formalizing Lateral Relations

In the beginning of this report, diagrams were utilized to show how communication among and between the agencies would ideally work to address groundwater issues. One of the issues that has repeatedly surfaced in this discussion is the need for *lateral* communication among individuals and groups that need to work together, but are located in different agencies. An ideal committee structure to develop lateral communications among the agencies was outlined in Figures 30 and 31. There are real world problems, however, that have to be resolved. If each of the agencies represented in Figure 31 insist on *coordinating* rather than *integrating* its groundwater programs, then each group will maintain its own contingent of research and technology transfer programs. As presented in Figure 32, the failure to develop an integrated interagency program-oriented management group results in a confusing mix of independent programs. However, the limited efforts of the coordinating group are much to be preferred to the chaos that issues when there are no official coordinating mechanisms at all and each office attempts to coordinated with all other pertinent programs. As illustrated in Figure 33, confusion reigns when each of the offices attempt to keep track of what all of the other pertinent offices are doing. Figure 33 shows only a selection of the pertinent offices, with only some of the necessary communications lines drawn in.

The difficulties created by a lack of clear coordinating mechanisms between the many offices is thrown into even starker relief when one recalls what these collective efforts are supposed to produce: coordinated and integrated plans for managing farms in ways that will protect groundwater quality. Figures 34 and 35 diagram some of the components that will be involved in total farm management. If the farm management components in these figures were overlain with the agency offices that have programs that impact each component, the resulting diagram indicate a logistical nightmare. Clearly, formal communications and coordinating mechanisms need to be maintained among the offices.

- Detailed staff

One important solution to facilitating communication among the offices and agencies is for them to *borrow* each others staff. Nothing facilitates understanding of an office's operations like working in the office. The agencies have tried this, in some capacities.

> I would also note that USDA's Soil Conservation Service has employees stationed at each of EPA's regional offices, and one USDA employee is currently on detail to EPA Headquarters in Washington to provide assistance in inter-departmental coordination (Mussman, 1989).

As well, some of the agencies have detailed staff to Congressional offices, committees, and OMB. However, the number of staff that are detailed to other agencies is very small compared to the total number of staff in each of the agency. Formal mechanisms and reward systems should be established to insure greater interagency *cross-fertilization*.

- Task Forces, Commissions and Coordinating Councils

An arrangement enabling one to share the blame with others.

-- Franklin P. Jones
(Webster, 1988)

Both the need for coordinating groups and their limitations have been considered in the course of this paper. As discussed, there is a need for coordinating groups, but they must be carefully crafted and empowered in order for them to be effective. Congress often mandates the involvement of agency administrators in such coordinating councils, but there are several problems with this approach. First, agency heads have many other concerns and may not be well acquainted with details of the specific programs that are to be coordinated. Second, they are very busy people and usually send other people in their place. Third, the person that gets sent to these meetings is usually not one of the people actually running programs and doesn't know details either. The result can be that people who actually show up at such meetings don't understand the problems and don't have authority to resolve them if they did. The end product of such meetings is usually reassurances that good things are being done somewhere by somebody. The old Water Resources Council is a classic example of an coordinating group that retreated into information gathering, then disuse, then collapse as a result of administration antipathy (Foster and Rogers, 1988).

If coordinating councils are mandated, it is important to make it very clear what types of products are expected from the group, and to make sure that technical staff and actual program managers are incorporated in the deliberations.

The ideal coordinating council evolves along the lines of an 'Excellence Network'. Technical specialists and program administrators identify each other, devise integrated programs, and they explain to their administrators what needs to be done. The agency administrators are incorporated into the process to resolve jurisdictional disputes, legitimize the process, and to work out budget and management problems. It is difficult to mandate this kind of process, but it is possible to provide a conducive environment rather than a hostile environment. In essence, it requires an iterative process between technical staff, program managers, and agency administrators, rather than management by fiat. This iterative process is underway within the agencies, but the process is still in a beginning phase in the development of integrated plans among the agencies.

If coordinating councils are going to be used, it makes sense to make sure that an entire structure of coordination is in place, from agency administrators down to the field specialists. These councils should have adequate support staffing to ensure the completion of mandated projects within defined time periods, but not so much staffing as to add another layer of paper-generating bureaucracy. A clearly defined set of coordinating groups, with defined authorities, would help resolve the current confusion regarding the roles and responsibilities of the existing coordinating groups. One *package* of coordinating councils include the following:

(1) **Presidential Interagency Commission on Water Quality**

Made up of administrative heads, OMB, and senior executive responsible for water quality coordination within each of the appropriate agencies. This Commission should be used to resolve territorial disputes between the agencies, approve and legitimize interagency plans and budgets, and wield necessary authority to mobilize lagging programs.

(2) **Agency Councils on Water Quality**

Made up of the senior administrators of the appropriate offices within each agency. These councils would serve the same basic function as the Commission, but within their respective agencies. Each Council would report to the head of the agency, in order to ensure integrated planning within each agency.

(3) **Groundwater Protection Program Managers**

Within each agency office, the managers of groundwater programs are most aware of the administrative problems that have to be resolved. They need to coordinate their respective efforts and report to their office administrators.

(4) **Technical Integration Groups**

Within each program, scientists and technicians have the best understanding of the problems that the programs are trying to solve. These experts need to work carefully with the program managers to design and implement program. The TIG's should also be used to design interagency programs. The administrative details of these projects need to be worked out among the program managers, and then sanctioned by the interagency Commission.

The same organizing structure of committees then needs to be duplicated for Regional Councils, State Councils, and local Councils. This sounds like a tedious collection of committees, but in truth, there is already a broad mix of such committees addressing water quality issues. The respective responsibilities of these groups should be defined and integrated into a comprehensive planning process.

- Integration

As discussed previously, coordination is necessary but not sufficient. The difficult but critical step is integration. The use of Technical Integration Groups to facilitate this needed integration has been advocated. The structure and functions of such groups are outlined in Figure 36 and Figure 37 respectively. Within the coordinating groups and within the TIG's, there needs to be individuals assigned specifically with the responsibility of program integration.

Program integration requires unique talents and capabilities. Farmers and producers deal with one domain of priorities and problems. Scientists communicate in their dialects of jargon in a separate domain of priorities. Administrators function in yet another realm as they try to keep troops pointed in the right direction. Policy-makers struggle to broker public sentiment into public law. Rare and few are individuals that are fluent in the dialects of each of these communities and fewer are those that can travel freely among them. Among other responsibilities, the Extension Service is supposed to provide translation and communication between producers and scientists. But the Extension Service lacks personnel (ECOP, 1985), training and resources to successfully complete this technology transfer circuit for all of the many diverse issues they are directed to address.

A new *hybrid class* is needed of scientist-farmers, scientist-administrators, and scientist-policy-makers trained to communicate and facilitate translation and communication up and down on the management continuum, as well as laterally among agencies. Such individuals would be responsible, for example, for assessing ongoing research efforts and translating their policy implications to policy-makers. Likewise, such individuals would have to explain policy concerns of the larger public, and interpret implications of these concerns on research priorities. An option for Congress would be to facilitate development of these technical-policy hybrids, by supporting development of new training and education programs and by developing special scholarships and grants for *hybrid-studies*.

The integrator is different from a manager in that the manager supervises actual work, while the integrator coordinates the managers, both vertically and laterally: "The integrator's role is not to make the best decision but to see that the best decision gets made" (Galbraith, 1973). The integrator operates by establishing contacts and linkages, developing trust, and managing the decision making process. The integrator needs a technical understanding of issues under consideration, a grasp of policy implications of the issues, the capability of transcending the mind set of particular disciplines or administrations, and the capacity to speak the languages of the different specialties which are party to the decision (Galbraith, 1973).

While it may be difficult to identify many potential groundwater quality *integrators*, it might be possible to identify personality traits that are conducive to developing integrator capacities. Identifying appropriate personality types for a unique job may be a new concept to the Federal agencies addressing groundwater problems, but it is a technique that has been used for years by the military and by private industry. Individuals vary in their ability to do certain kinds of tasks, and the capability to do certain kinds of tasks can be identified and selected. It may not be necessary to develop such selection criteria for most positions, but it may be critical for some positions.

In the case of identifying program integrators, there are some specific characteristics of interest. For example, individuals vary in their capacity to stand between two conflicting groups without being absorbed into one party or the other. Some manage to be rejected by both parties. Studies thus far have suggested that some people are most strongly motivated by a need to achieve, while others are motivated by a need for affiliation. Those likely to be good integrators will likely have both motivations. While few integrators may be found today, it may be possible to *grow our own*. Just as development of scientist-policy makers can be facilitated, identification and training of integrators can be developed as a new aspect of Federal agency management. Many agencies have personnel assigned to generic liaison roles, these individuals are supposed to resolve a broad array of communications issues that come up between the agencies. Such individuals usually lack the technical training and skills necessary to integrate actual programs in topical areas such as groundwater protection.

A critical problem facing integrators is one of *power*: how can they influence the decision making behavior of individuals who are in other agencies, or who are above or below, but not under, their authority? In an age where information is often the currency of power, the integrator can leverage power by brokering access to information that is available. However, inadequate knowledge or great uncertainty, will make it difficult for the integrator to gain enough leverage to resolve serious conflicts.

When persistent conflicts develop among the coordinating councils, problems may have to be appealed to integrators with authority in the next level of the coordinating councils. For example, if the integators within the USDA and USEPA Coordinating Committees cannot resolve differences between program managers in their respective agencies, the problem would have to be directed to the Interagency Commission.

D. DEVELOPING AN INTEGRATED INFORMATION AND DECISION-MANAGEMENT SYSTEM FOR GROUNDWATER PROTECTION

1. ESTABLISHING MATRIX MANAGEMENT: THE MISSING STRUCTURE

The implicit assumption underlying the use of matrix designs is that we cannot find authority structures in the form of product divisions,

> regional departments, programs, functions...which will encompass all the activities which required coordination. There is a major defect in any choice we might make. In addition these defects may not be corrected by the informal organization which can arise to walk across lines of authority.
>
> -- Jay Galbraith.
> Designing Complex Organizations (1973)

In preceding sections the argument has been made that Federal agencies need to develop the capacity to institutionalize communication across agency boundaries to facilitate integrated and coordinated groundwater management programs. It has been argued that rather than reorganizing the government every time a new social concern arises, that it is necessary to ensure ready identification of appropriate entities within each agency and to assess what they are doing, identify and eliminate areas of overlap and neglect, and develop an agenda to coordinate ongoing efforts. Whatever the social issue, there will always be some degree of tension between organizing by projects and organizing by existing institutional functions. The point is to develop mechanisms that allow a successful synthesis and integration of both programmatic and administrative goals.

To this end, use of a *matrix* is a helpful planning and prioritizing tool. USGS introduced the concept of using matrices as a planning device in the early TIG meetings. They proposed that the respective components of the hydrologic continuum be identified on one axis, and the physical processes that effect movement through this continuum be identified on the other axis (Figure 38). The resulting research matrix could be used to identify which scientific disciplines were pertinent to each hydrologic component, which would then serve as a rational basis for deciding who should be coordinating to address each set of issues. Once the basic design of the matrix is agreed upon, a list of possible activities can be generated and prioritized in the context of the matrix.

In the TIG meetings that followed, the research matrix evolved into a program matrix. After a series of meetings, the diverse research topics pertinent to groundwater protection were sorted out and identified on one axis, and the involved agencies and offices were identified on the other axis (Figure 39). Each of the topical areas identified on the vertical axis encompass a range of prioritized research projects, which are listed in Appendix 9. In this matrix, areas of specialization, and program overlaps or gaps become apparent. The concepts underlying development and use of *management matrices* are described further in Appendix 9 and in articles by Nipp and Ragone (1990). The use of this matrix to prioritize and consolidate an extensive list of groundwater research topics is shown in Appendix 9.

Another dimension could be added to the program matrix in Figure 39, and that is *scale*. Each of the listed Federal agencies will have to integrate their programs down through their administrative structures, as well as with each other.

For example, national program administrators at USDA/CSRS and USGS/WRD may agree to coordinate in the development of diagnostic tools. However, each has regional and State programs that will have to be incorporated. The addition of *scale* adds a third dimension of *depth* to this matrix model. Figure 39 could be envisioned as the top layer, underneath it are regional, state and local program matrixes. Program integration needs to be coordinated vertically within agencies, as well as horizontally among agencies. This may all sound rather complex. However, matrix management does not cause this complexity, it is rather a tool to impose order and study programmatic interactions where complexity already exits.

When such a three dimensional program matrix is actually implemented, a *dual reporting system* becomes necessary. Information must flow in each dimension: laterally among organizations and vertically within organizations. Dual reporting may seem cumbersome and potentially redundant, but it is a reasonably efficient alternative to restructuring existing institutional boundaries. At this time, groundwater program information is flowing reasonably well in each dimension. Most agency participants have a fair idea of the activities of their own agencies, and agencies appear to have a working knowledge of each other's programs. However, participants may not have a detailed knowledge of program activities. As witnessed by the annoyance and confusion when SCS announced its choice of 37 hydrologic units, there is not yet a complete flow of information in each direction. Moreover, most of the communications networks now in place are informal and personal. There are no formalized communication structures or tools in place, such as interagency newsletters, bulletins, or computer bulletin boards.

In the earlier discussion on program integration, the role of the integrator was identified. The integrators role can be defined in the context of matrix management. In a sense, the integrator serves to cement linkages in a 3-dimensional matrix, where hierarchical authority exists on the vertical axis and institutions and program activities exist on other two axes.

OMB, FCCSET, and a number of committees are yet struggling with the agencies to identify which agencies and offices are involved in which programmatic areas and what responsibilities should be assigned to which offices. Matrix management is a planning tool that might help these groups clarify and visually demonstrate the relative roles of each agency and office.

2. Strengthening Vertically Integrated Information Systems

The ability to simplify means to eliminate the unnecessary so that the necessary may speak.

-- Hans Hofman
Search for the Real

However bureaucratic structures are organized, groundwater program managers and scientists need specific, succinct, and timely information. In the earlier discussion regarding optimal organization structures for groundwater management, it was suggested that agency administrators organized on a programmatic basis need to have access to 'vertically integrated information systems' (VIIS) in order to keep in touch with information flow within their home agencies. A VIIS is basically a communication and information network that operates vertically within an organization. For example, a national program leader in Washington may need to know what kind of nitrogen management programs are underway in Lancaster County, Pennsylvania. The administrator can get on the phone and call Lancaster County, but what if they need a concise summary of the program activities underway in 100 counties in the northeast? Similarly, a scientist in a State university may wish to know what the effects of new groundwater protection legislation are going to have on USDA and their programs. One scientist could call into Washington, but what happens if they all want to call in?

Presently, there are information management tools in place and communication networks that are operating, such as the CRIS system discussed earlier. However, these components are not really integrated into a comprehensive VIIS system to manage groundwater protection information. At present, the problem is not a dearth of information. It is all too easy to get buried in a flood of relevant but non-helpful information when trying to make groundwater management decisions. Rather, the problem is being able to isolate specific information on program activities out of the flood of information that is available. It will be difficult to develop adequate flows of information between the agencies, when information flow within the agencies is still a tenuous process. The need then, is to develop an integrated information system that incorporates the needs of all participants in the system, from policy-makers in Washington, to researcher and educators out in the field.

a. Keeping Track of Who is Doing What and Where

As evidenced in the section regarding program management and accounting, some of the agencies are in need of serious help in developing adequate program accounting mechanisms and protocols. It may be tedious and alarming, but it may prevent serious problems in the future if OMB or GAO reviews current program accounting systems within the agencies. Where critical weaknesses are observed, new accounting and record keeping systems should be required.

In addition to accounting for the allocation of funds, it is necessary to keep track of what programs are underway, and where. Systems like the CRIS system do exist, and can well serve the functions for which they were created. However, these systems were not designed to readily provide answers to some of the questions asked by policy-makers and program managers. As demonstrated in the discussion regarding State expenditures on groundwater research, individuals had to go through the CRIS results by hand and categorize the results. CRIS provided the essential *first cut*, but the next step were not built into the system. A system needs to be developed that can track the diverse programs that are underway in the States, so that they can be integrated with national programs. Another key issue is to make sure that the paperwork involved is not so tedious or overwhelming that the resulting burden is greater than the information benefits that result. As well, it is important that program information is stored in such a way that it can be easily searched and retrieved.

One option is to expand the operations of the CRIS system, or develop something with similar but expanded capabilities. If the CRIS system is modified, it would be a relatively simple matter to add yet another page to the paperwork that researchers fill out, so that they categorize their programs more specifically on the basis of current issues of public concern. This way it would be easier to determine how many scientists have programs underway to study groundwater contamination, or global climate change, or whatever. Another aspect would be to expand the progress report component of CRIS, so that it would be possible to determine when the projects were likely to finish, and to determine what results could be anticipated. Other types of programs, such as technical assistance or education, could be incorporated into a total program tracking system.

There is a fundamental problem, however, with this approach. It requires that each individual describing a project make a largely intuitive judgement about relevance of their work to different areas of social concern. The problems described earlier in regards to the agencies inability to consistently categorize their program activities would be increased by orders of magnitude. To coordinate and integrate groundwater programs, there must be some agreement on the definition of groundwater programs. Until programs can be consistently categorized, there is no possibility that the fundamental auditing problems addressed earlier will be resolved. There can be no resolution to the question of how much money is being spent on groundwater research if there is no agreement over what groundwater research is.

b. A Classification Algorithm

Congress might choose, then, to require establishment of some agreement within and among agencies as to what exactly constitutes a groundwater protection program. In actuality, this classification may be a very difficult task. Certainly, it will be a politically charged task. Nonetheless, it should be possible to reach some classification algorithm to determine relevance of ongoing efforts to groundwater protection. This algorithm would essentially constitute an agreed set upon rules for defining the different type of groundwater programs that are underway. The FCCSET report provides an attempt to show how much the agencies were spending in different types of groundwater work, though it is not clear that the criteria were well established or defined for reaching the numbers that resulted. The research categories identified by TIG (Appendix 8) could serve as a starting point for developing a list of agreed upon categories of groundwater protection work. The rules for assigning projects to particular categories could then be designed. Projects could, of course, fit into several categories. However, rules to define how much of each project will be assigned to each of the categories could be established.

Once programs are assigned to a category, they need to be described. An algorithm, or set of decision-making rules could also be developed to define activities. One descriptive scheme could determine whether work is (1) directly relevant, (2) potentially relevant, or (3) remotely relevant. The criteria for each of these classes will have to be carefully defined. A second criteria should indicate whether work is primarily (1) collection of data and samples, (2) analysis of research and data collection, (3) management of people involved in the above, or (4) development of policy or regulations resulting from the preceding activities. This kind of information would make it possible to separate programs on the basis of their functions and to then have a basis for analyzing the returns on investments made. For research projects, one would expect a high percentage of the sponsored programs should support collection of data and analysis. If a lot of the funds show up in management of people, then the relative funding priorities of the research programs might be legitimately questioned.

A sample of a very simple classification algorithm is provided in Figure 40. The important aspect of this figure is that it shows that the algorithm can be formulated very much like a computer program. Getting everyone to agree to a set of classification decision-making rules will be difficult enough. Asking everyone to then work their way through complex rule books for describing their projects is doomed to failure. However, once the rules are agreed to, computer programs can be written to do the difficult work. Basically, *artificial intelligence* programs could be developed that would ask participants a series of questions to describe their programs and activities. No paperwork would be required. It would be a relatively simple matter of responding to questions. The algorithms encapsulated in the software program would then do the difficult categorization. Since the information would already be in computers, it would be easy to send the resulting information through modems to the Federal agencies, to compile and analyze.

c. Program Tracking Information Systems

The development of intra-agency classification algorithms is relevant to a broad range of issues. Persistent irritation develops between Congress and agency representatives when an agency cannot readily explain how much work it is doing on a particular problem. From the Congressional point of view, that should be one of the easiest questions to answer. It does not help matters when the agency provides more than one estimate, depending on which office is asked. Congressional staff have also indicated that they are annoyed when they add up numbers provided by an agency regarding its activities in several issue areas and discover that the total is four or five times larger than the agency's total budget. Congressional interest in developing tracking programs is evidence in the groundwater protection legislation introduced in the 100th Congress. Many of these bills included provisions to create national *Clearinghouses*, so that it would be possible for people both inside and outside the agencies to identify relevant programs and to track what is being done by the agencies.

As bad as it appears, the agencies' problems in keeping track of their activities are understandable. Programs and research, particularly basic research, can be relevant to a broad array of popular issues. Moreover, the popular issues change over the years and it is tedious, cumbersome, and difficult to continuously and retroactively analyze on-going projects for their relevance to new areas of topical concern. Nonetheless, is also reasonable for Congress to ask for agencies to define what they are doing and to expect a reasonable approximation.

With the use of agreed upon classification algorithms in place, it would be possible for Congress to ask the Federal agencies how much they are spending on groundwater data collection, research, education, and technical assistance, and get a number that could be well defended. Similarly, program administrators could take the program matrices that have been described and determine how much funding and personnel are involved in each category of the matrix. Areas of deficiency should then be immediately apparent. It is true that the numbers that are generated by this process will still be approximations, but they will be infinitely better than those resulting from the kinds of guesses now being made by some offices. One agency staff member was questioned on the amount of dollars his office claimed to be spending on groundwater protection. He glibly confessed to having made the numbers up, but then he argued that the numbers were about as good as anyone could get anyway, which was probably true. Unfortunately, the numbers generated by offices that have a reasonably good capability of describing their program activities, such as CSRS with their CRIS system, can be lumped together with offices that have no capacity whatsoever to describe their activities.

As an option, Congress might wish to require that the agencies jointly support an evaluation of current program tracking data bases and evaluate their relative utility. Based on this evaluation, an optimal 'Program Tracking System' could be designed, using the classification algorithms previously described. If Congress is interested in developing this system just for groundwater protection from agrichemicals, a logical home for such a system might be the National Agricultural Library. If Congress wishes to consider developing this system to keep track of the larger array of environmental and social issues, then it may be advisable to house the system in a *neutral* home. FCCSET has the appropriate integrating mandate, but lacks the administrative infrastructure. OMB has integrating responsibilities and the administrative infrastructure. A third alternative would be to create an agency for information and data management, that would serve to provide program tracking and data integration services to the other agencies. The danger of this last alternative is that it might end up being necessarily duplicative of internal agency activities. If the program tracking system is housed in OMB, a comprehensive program tracking system could be devised, but each of the agencies could maintain their component. Each agency would feed into the OMB system, which would then have the data that it needs to evaluate program for budget development.

E. Putting the Pieces Together

To optimally coordinate and prioritize activities through technical integration groups, matrix management, and information management tools, these activities need to be integrated into a comprehensive decision-making system. Such a comprehensive system will require facilitated communication, access to coordinated data bases, capabilities to model and predict the outcome of actions taken, tools with which to visualize available information, and instruments with which to incorporate these resources into the decision-making process.

1. INTEGRATING INFORMATION AND DECISION MANAGEMENT

a. New Vistas in Information Communications

It has been argued that technical specialists and groundwater program administrators need ready access to each other regardless of their institutional affiliations. In addition to the administrative and information management systems that have been suggested, greater use can be made of some of the information transfer technologies that have evolved. It is now possible to greatly speed up the transmission of new ideas and to facilitate communication among scientists across disciplinary and agency lines through the use of computer networking and bulletin board services. These systems can provide the mechanical means to implement the information flow necessary for the described technical integration groups, matrix management, and vertically integrated information systems.

As discussed and illustrated in Appendix 11, computer bulletin boards are already being used by some scientists as forums for the exchange of new information and for synergistic program development efforts. For example, a computer bulletin board at USDA/ARS was used to develop the background documents used for the agricultural components of FCCSET's plan to address global climate change. An 'Excellence Network' developed electronically as scientists drew in appropriate specialists to add necessary components to the electronic document. Scientists from different agencies and disciplines logged onto the system, contribute their portions and reviewed the whole. The process was completed without their having to ever meet as a formal committee or working group.

In addition to such bulletin boards, work is underway to develop electronic journals so that scientists can transmit the results of their work much more readily. Considerable progress is being made in the area of graphics transmissions, which make it possible to electronically disseminate charts, graphs, diagrams, maps, and even pictures. In such systems, scientists will be able to search for appropriate journal articles electronically, download appropriate references to their own computer, and *cut-and-paste* appropriate segments. Even more important, they will be able to transmit *data packages* along with their research results, so that collaborating scientists can more readily test, verify and build on each others work.

Computer linkage networks will make it possible for the appropriate experts to communicate and organize around topical issues such as groundwater, without necessarily having to change or reorganize their respective institutional structures. For example, a scientist may be doing a project that is relevant to both groundwater protection and climate change, such as methods of nitrogen fertilizer application. Through computer networks, the scientist could readily communicate with others in each of the two topical fields, without having to belong to separate agency programs. As well, there are tremendous implications for extension and education outreach programs (Appendix 11E4).

The application and availability of computer networking systems is very uneven. As the Extension Service was developing a computer water quality network, the planners were dismayed to discover that many in the planning group themselves did not have access to computers with modems (Swader, 1989). Only a small percent of farmers have computers, and therefore most would not have access to the kinds of information transfer that would become available (Appendix 11). In many state and county offices in the different agencies, computers are used only as *glorified typewriters* (Hoag, 1989). There is a pressing need to evaluate the current status and future needs for the development of integrated computer systems in agriculture, particularly for the areas of farm management and environmental protection. It is time for an in-depth study of these issues, possibly by the National Academy of Sciences.

b. Coordinated Data Base Systems

> Better, more accessible baseline information is needed for assessing trends in water quality over time, both locally and Statewide...Agencies or utilities armed with more timely and accurate water quality information could make better management decisions and avoid ineffective solutions aimed at the wrong parts of the drinking water systems (Univ. of Calif. Water Quality Task Force, 1988).

In addition to tracking ongoing groundwater research and program activities, there is a clear need to coordinate the many relevant data bases and information sources that already exist. As discussed in Appendix 5, there are many environmental, economic, and social parameters that would be relevant to the inquiries of a groundwater research scientist, educator or policy-maker. It would be clearly advantageous for groundwater scientists to have access to relevant information in the data bases at --

- NOAA and the Agricultural Experiment Stations for relevant climate information such as precipitation and temperature;
- TVA, for data on nitrogen use;
- USDA/SCS, for soil types data;
- USGS data on hydrological units and groundwater aquifer mapping;
- USDA/ASCS, for data on cropping patterns;
- USDA/ERS, USEPA, and Resources for the Future for their respective information on pesticide and nitrogen use; and
- USDA/ERS data on vulnerability to nitrogen contamination.

The problem is that while many pertinent data bases do exist, they were created autonomously to address different fundamental questions. For example, USGS scientists might create a data base that includes information on the movement of the herbicide Atrazine through the soil profile. They might measure parameters relevant to the chemistry and physics of chemical transport through the soil, but as hydrologists they might not think to include particular measurements of tillage practice or rainfall patterns, information that would be critical to an agronomist trying to develop new cultural practices to minimize the movement of Atrazine out of the root zone. A simple preliminary consultation with potential outside users of such a data base could save a tremendous amount of money and effort by adding a few extra measurements in the data base format. In this example, the whole study would have to be repeated to be of use to an agronomist.

Even if the right parameters are included in a data base, the system of information search and retrieval is often unique to each data base system. Consequently, much data has been collected that is relevant to groundwater protection, but much of it may be in an inaccessible or unusable format for scientists from other agencies. Efforts are already underway, both in USEPA and USGS, to define data entry protocols and standard formats such that future data bases might be more integrable. USEPA conducted a workshop to "Recommend A Minimum Set of Data Elements for Ground Water" (USEPA/OGWP, 1988). It was proposed that a minimum set of parameters for groundwater data bases should include elements that:

- are needed to communicate groundwater data across programs,
- are common to all programs, but completely adequate for some programs,
- provide a road map to other data, and

- provide a link between water quality and location information.

To create such data bases, the workshop concluded that certain implementation issues that will need to be resolved, including:

- The need for the commitment and cooperation of all other relevant Federal agencies to ensure the collection of a minimum set of data elements for ground-water.

- The need to develop as soon as possible a data dictionary containing definitions of the elements. Early development of the dictionary would increase the probability of its incorporation into many data management systems currently under development.

- The need to develop a common format for key minimum data elements to compensate for the present lack of data standardization.

- The need to establish links among key ground-water data systems which would allow data managers to store data locally but easily transfer data among systems.

In recent Congressional testimony, Dr. Mussman, Deputy Assistant Secretary of Science and Education (USDA) stated that the Economic Research Service, working with other Federal agencies, will be initiating projects to:

- estimate pesticide use by State, analyze the effects of new management practices, assess the impacts of pesticides on productivity and profitability, and evaluate the consequences of pesticide regulations;

- develop computerized maps for analysis of land use in relation to soil characteristics and water quality; and

- coordinate projects with the Environmental Protection Agency and the U.S. Geological Survey to cross-reference these data bases (Mussman, 1989).

The scope and limitations of these beginning efforts are discussed in greater detail in Appendix 12, which includes: a summary of the data base needs for groundwater protection that were identified in the Our Changing Planet: The FY 1990 Research Plan (Committee on Earth Sciences, 1989), examples of currently available data bases, and a discussion of software programing that is available to integrate data bases into the decision-making process.

One of the working committees of the Technical Integration Group is examining the standardization of research protocols and standards for groundwater work. A workshop on sampling protocol was held by USDA/CSRS in the Fall of 1988, and according to Dr. Mussman, a workshop on data integration is being planned (Mussman, 1989).

The coordination of available data bases into an integrated information systems poses more of an administrative challenge than a technical problem. The technical issues are not trivial, but the necessary technology to address the difficulties that are involved already exists; it's a matter of developing the applications. The political and administrative issues may be more difficult. Each of the agencies may resist changing their own systems to adjust for outside users. In some instances, it may be embarrassing to have to admit to some of the inadequacies of the data in their systems. As well, there may be considerable reluctance among the agencies to house all of their information at some form of clearinghouse that is located within only one of the agencies.

Congress may wish to require the creation of a coordinated data base network, in order to insure that the agencies resolve their administrative difficulties in a timely fashion. The development of this system might involve developing rational interfaces between the existing data bases, with standardized data entry, formats, and search protocols. Another alternative would be to aggregate all of the relevant data bases into a national data base clearinghouse. Each of the agencies would maintain their own systems, but periodically *upload* their data to this national Center. Such a data clearinghouse could establish national formats for specific sets of environmental information. As agency programs produce groundwater data they could be required to provide the minimum set of measurement parameters included in the national format. Specific agency programs could, of course, run studies that included measurements beyond the minimum data set, and they would be expected to do so, but this way there would be an agreed upon set of measurements that scientists could depend upon.

The problems inherent in finding a *home* for this Center are similar to the problems of finding a home for the proposed *program tracking system*. Again, if Congress wishes to focus on groundwater and agricultural production, one solution would be to establish a central data base clearinghouse at the National Agricultural Library. If Congress prefers to address data base integration for the broader array of environmental issues, it may wish to create a separate office for Environmental Data Acquisition, Integration and Management (EDAIM). EDAIM could be established within a *neutral* data collection agency, or it too could be housed within OMB. The agency components of the system could remain housed within the agencies, but OMB would provide the integrating structure and mandate.

A fundamental weakness of many of the current proposals to develop a national clearinghouse for groundwater data is that they have top-down structures. In a number of bills introduced in Congress, there are proposals to collect groundwater information from sample points, which would then be housed in a national clearinghouse. The problem is that a tremendous amount of money could be spent to develop such a system without obtaining the site-specific data that will be necessary for researchers, educators and farmers to make *real-world* decisions. For example, a national data collection program could collect groundwater monitoring data from 5 sites in every State. The result would be more than 250 monitoring sites, each of which could provide a mass of monitoring data. From the national level, this looks like a lot of data collection. However, from the State's perspective, 5 sites make up a very small sample of the many diverse environmental conditions within the State. Farmers still have to account for the unique hydrology, climate, soils, cropping patterns, and economic resources of their individual farms. The data from the 5 sites in the State may have little to no bearing on their particular circumstances.

A far more effective strategy will be to create a national format for data collection, so that as site-specific information becomes available it can be coordinated from the bottom-up into a comprehensive national system. Such a system would aggregate information upwards to evaluate national trends and needs, rather than extrapolating the results of a national program downwards. Moreover, such a system would provide a more accurate national picture, while allowing resolution down to the local decision-making level.

A variation on the concept of a national data clearinghouse for groundwater would be the creation of a universal search program. Rather than having to learn the language or search protocol for each of the data bases, or wait till the information is transferred to a national clearinghouse, individual inquirers could log-on to an interactive search program that would ask them a series of questions. On the basis of the answers to the questions, the program would then *dial-out* to the appropriate data bases and retrieve relevant information.

c. Modular Models

It is important not to lose site of the end for which collecting data is the means. Data should be collected to do something: specifically, data should be used to provide information from which one can make some sort of decision. The *decision* can be an improved understanding of how the world works, or it can be a decision about what action should be taken, or it can be a decision that more data will be necessary to make any decisions. In any case, a working model of the world will be used when decisions are made using the data that has been collected. The model may be a formal computer paradigm, or just an informal set of assumptions.

In the case of groundwater management, as well as other environmental issues, the number of variables and parameters of concern are becoming so numerous and the interactions between these factors so complex that there is an increasing reliance on computer models. Computer modelers, in turn, are discovering that environmental modeling is an enormously complex and huge undertaking. Consequently, discussions are well underway regarding the development of modular modeling. The idea is that individual researchers and teams will proceed to develop the particular models for which they have interest and expertise, but that they build the *input* and *output* components of their models according to agreed upon standards, so that other scientists can take models developed by others and incorporate them, without having to repeat work that has already been done by others.

By way of example, a scientist could develop a model of nitrogen movement trough the soil, another could develop a model of how plants absorb nitrogen from the soil, another could develop a model on nitrogen volatilization and yet another could develop a model of how nitrogen leaches through the soil profile to groundwater. Each of these are substantial and important projects. However, left as individual projects they would not be able to help answer very fundamental questions on how to balance nitrogen fertilizer applications so as to ensure healthy plant growth while protecting groundwater resources. However, if the models are developed according to agreed upon standards, an integration team could concentrate on the interactions of the models and put them altogether into a comprehensive nitrogen management model.

To be pertinent to farmer decision making, management models have to incorporate economic and management factors (Figure 41). Incorporation of economic forces and government programs is critical, but is clearly a large undertaking. The outline for modeling a single crop is shown in Figure 42. The crop model, in turn, must be integrated into other markets and programs, as shown in the diagram of livestock sector linkages shown in Figure 43. In addition to market models, the relative impacts of the production practices used on the environment need to be weighed (Figure 44).

There are difficulties in developing modular models. Examples of current efforts to use modeling and monitoring in groundwater management are provided in Appendix 13. Examples of some additional relevant modeling efforts are included. As well, excerpts are provided from a computer bulletin board forum on modular modeling, which provides insight into the philosophical and pragmatic issues involved in the development of this science.

d. Information Visualization

The old adage that a picture is worth a thousand words is particularly appropriate in data analysis and evaluation. A book of numbers is not nearly as informative as a map that shows aquifers with high risk areas highlighted in red. Consequently, there is considerable interest within each of the agencies in the development and application of Geographic Information Systems (GIS). GIS systems can take the data available from diverse data bases, and generate visual maps that can be overlain (Bartholic, 1987, Burrough, 1989). As shown in Figure 45, such map overlays could include cropping pattern information, herbicide detection measurements, natural resource parameters and political boundaries. The combination of these data bases and maps can make it instantly clear where the areas of greatest risk are located.

An introduction to GIS systems and their potential application to environmental issues is provided in Appendix 14. Basically, a GIS system requires a comprehensive set of computer programs to take data from the diverse data bases, to transform data into maps, to display the results and to interface with users (Figure 46.1). The problem of transferring the data from existing sources into a usable format is not a trivial issue (Figure 46.2). By way of example, the current status of SCS in digitizing their soils data map is provided in Appendix 14. This is an expensive process. SCS has had difficulties securing funding to digitize their soil maps so that they could be used in GIS systems. The estimated cost to complete the digitization of soils maps for the entire country could run well over $25 million dollars (Burt, 1989). Once the data is transformed (Figure 46.5), it has to be organized into a complete and integrated system (Figure 46.6). In the case of the soils maps, the absence of Federal support has led a number of the States to proceed on their own. Unfortunately, the States are not all using the protocols proposed by SCS, so the *pieces* of the national system are not likely to fit together well.

An example of a completed GIS system is provided in Figure 47. In this example, the environmental parameters that affect maize production were identified. The various parameters were mapped and overlain to identify areas with high suitability for maize production. The flow of information used in this example is outlined in Figure 48. Many groups are studying the use of GIS systems. GIS systems have been used for some time by USGS, American Farmland Trust, and some Land Grant Universities and State Agriculture Experiment Stations, such as the work underway on Soil Survey Information Systems in Minnesota (Anderson and Robert, 1988). USDA, USEPA and others are showing increasing interest in these systems and are including proposed uses of these systems in their planning documents.

GIS systems will serve as critical resource management tools for scientists, educators, and managers. For example, using the coordinated data base system previously described, a regional map might be created that shows the underlying hydrology; a second may might be created that shows soil types; a third may might show cropping patterns; and a fourth map might show precipitation patterns. Each of the maps might be interesting in themselves, but if the maps are overlain, the information they provide can be tremendous. Parameters that indicate high vulnerability to pesticide contamination of groundwater can be identified and color coded. In this example, the map overlays might identify high risk circumstances to include a karst topography, sandy soil, heavy corn cropping, and heavy rainfall. An overlap of several or all of these features would indicate an area of extreme risk.

The use of GIS in groundwater protection should involve the following steps:

- Define meaningful hydrologic units using information provided by USGS and others.
- Develop GIS maps of hydrologic parameters of particular concern to groundwater management, such as the presence of a fractured karst topography that facilitates rapid transmission of chemicals to groundwater.
- Develop GIS mapping systems for each of the data bases described

previously.

- Identify data bases that do not yet exist.

An option for Congress is to mandate development of inter-agency GIS systems for management of groundwater protection, utilizing already existing data bases. Such a coordinated effort could be integrated into current OMB efforts to insure orderly GIS development within the Federal agencies, or could be managed through the creation of a coordinating technical integration group. The development of this system could also be handled through the created office of Environmental Data Acquisition and Information Management mentioned earlier.

e. Decision Management Systems

> An expert system can be defined as a hardware and software system that can mimic a human expert in a narrowly defined topic area. The most common type of expert system software consists of three parts: an inference engine, heuristics, and a fact base...One heuristic almost everyone uses when deciding whether or not to take an umbrella to work is 'if the sky is blue, then it is unlikely to rain.' That rule of thumb is not 100% accurate, yet we use it anyway, based on previous experience. Likewise, rules that experts use often have a degree of uncertainty (Myers, 1989).

Decision-making aids can include checklists, worksheets, rule books, and decision trees. These aids can be very helpful and practical, as illustrated by some of the examples included in Appendix 15. Criteria for evaluating the utility of decision-making aids is shown in Figure 49. Ultimately, decision-making aids are based on the sort of models discussed earlier. Making decisions implies an understanding of how the world operates. The more refined and tested the models, the better the decision aid will be.

Computer technology can be harnessed to produce very powerful decision-making aids. In addition to the development of GIS, data bases can be utilized in the development of computerized *expert systems*. An introduction to expert systems is provided in Appendix 15. In essence, expert systems try to mimic the *decision-making logic* of technical experts. Once established, these *expert rules* can be applied to much greater volumes of data than could be processed by their human models. As well, since expert systems mimic human experts, and since there is often a severely limited number of such experts, these systems ideally allow broader dissemination and easier access to expert analyses and advice. Many expert systems have already been developed. Just in the area of IPM, considerable work is underway:

> This is a management-intensive system requiring a great deal of site-specific data...I am advised that there are approximated 80 'decision aid' programs -- mainly software programs for personal computers -- available (Mussman, 1989)

Applied to groundwater management, expert systems could --

- assist farmers in the selection of appropriate fertilizer and pesticide application techniques and rates, incorporating economic constraints, equipment and labor availability, and environmental parameters;
- assist researchers and program administrators to identify and classify ongoing efforts; and
- assist managers, integrators, and policy analysts in identifying critical risk

areas and to assist in developing and evaluating management options. A number of expert systems relevant to groundwater protection are cited in Appendix 15.

Expert systems can aid farmers in managing their fertilizer and pesticide applications for their environmental and financial circumstances. Several *nutrient budget planners* are described in Appendix 15. It is even possible to take soil samples from a farmers field, analyze the nutrient content of the soil, combine the results of these soil tests with a digitized computer map of the soil types in the farmer's field, which can be stored in a computer housed inside of a tractor (Giese, 1987). The on-board computer can triangulate the positions of the tractor in the field at all times and control the amount of nutrients or pesticides that are being applied. There is often tremendous variability within a single field. Sandy soils may be interspersed with clay, areas with high nutrients in the soil may be interspersed with low nutrient soils. Using the described system would allow applicators to provide only as much of the chemicals or nutrients as are actually needed. This may sound like farming in the 21st century, but the technology already exists and is being used. A commercial company, Cenex, is already marketing the service and the computer systems. As for costs, any increase in expenditures is of concern, but the cost of such a computerized system is small compared to the cost of the tractor itself.

The current barrier to wider implementation of this ideal technology is the initial cost of digitizing soil survey maps, as previously discussed. For all of the decisions that will be made regarding groundwater protection, the availability of usable soil data maps will be fundamental. This is an area in which Congressional intervention could be immensely helpful. There needs to be a strong program to complete soil survey mapping throughout the country and to develop and complete standardized digitalization of these maps so that they can be used in decision-making.

Expert systems and models are also being developed to evaluate the interrelation of management policy and water quality impacts on agriculture. One example is the Comprehensive Economics Environmental Policy Evaluation System (CEPPES) of Iowa State University:

> CEPPES emphasizes the trade-offs between agricultural decisions, costs, and water quality. The model and approach are reflective of the fact that broad approaches to policy evaluation are important for studying relationships between agriculture and water quality. For agriculture, CEPPES includes farm-level, regional, commodity market, and sector-wide possibilities for evaluation of policy alternatives. The biogeophysical component of the system includes modules for air quality, plant growth, the root zone, groundwater, and surface water. Health and environmental risks are related to chemical fate and transport...CEPPES and other models are using analytical systems to supplement available limited data on impacts of pesticide regulation and alternative cultivation practices for chemical fate, crop yields, and water quality (National Governors Association, 1989).

When computer-based data bases, models and expert systems are combined, it becomes possible to carry out detailed, sophisticated analyses that integrate a wide range of issues and concerns. The components incorporated in the CEPPES system are diagramed in Figures 50-57 (CEPPES, nd). This concept is developed in greater detail shortly, and in articles by Nipp and Ragone (1990).

In the problems component of this paper, it was suggested that the agencies need to develop mechanisms to identify when the results of agency programs conflict or overwhelm groundwater protection objectives. Systems like CEPPES makes it possible to keep track of many diverse interactions between agency programs, and to suggest the possible impacts that changes in activities such as farm support programs would have on groundwater protection.

The next step in the use of data bases, GIS, and expert systems will be the integration of all three into a powerful information management and decision-making system, diagramed in Figure 58. The phrase 'Expert System/GIS/Data Base' is awkward, so yet another acronym is proposed: 'EGRET', for 'Environmental and Geographically Referenced Expert Technologies'. EGRET could have the following characteristics:

- Scientists and decision-makers could use interactive expert systems to identify data bases relevant to groundwater management;
- Information from these data bases could be obtained from a central groundwater data clearinghouse, or by use of a universal search program;
- Retrieved data information could be incorporated into expert systems to

identify program needs, research priorities, and high risk areas;

- This data can also be used in the testing and development of predictive models and decision-making aids to develop agricultural practices to protect groundwater;
- The process of developing models would provide *feed back* on what types of data collection and research are most necessary;
- Parameters associated with high vulnerability to groundwater contamination could be identified and data on these features could be incorporated into GIS to make it possible to visually identify and assess areas at particular risk;
- The program tracking system and classification algorithm would make it possible to identify relevant programs with results and resources that might be of use in protecting high risk areas; and
- The GIS could be housed within an expert system/model, which would allow decision-makers to produce visual representations of different options and scenarios, to determine the potential impact of policy choices on groundwater protection.

In this completed system, a decision-maker could look at a GIS map of a county and discover that a number of farms in the north-east corner of the county are at high risk because they are using heavy applications of root-worm insecticides on corn in an area with a shallow groundwater table. The decision-maker could propose various changes in farm practices, and visually examine the degree to which these changes modify the groundwater contamination risk. The decision-makers might propose eliminating the use of the insecticides and then examine the economic looses that would ensue. Alternatives could be evaluated, including reduced levels of application, changes in application methods, or the use of soybean rotations to prevent pest build-up in the soil. The economic and environmental impacts of each option could be visually represented and evaluated.

Another example: it might be determined that there unacceptably high levels of nitrate are being found in water wells in a particular region. Using this completed decision support system, it would be possible for a regulator to request information from appropriate data bases, identify parameters that enhance the risk of nitrate contamination of groundwater and then produce a GIS map of the region. The map would reveal that the groundwater table is very shallow in certain areas (from a USGS data base), that the soil type is determined to be sandy (using a USDA/SCS data base), and that high rainfall patterns are indicated (using data bases at the local Experiment Station). A regional map with overlays of these environmental parameters and contamination detection sites could show that contamination occurs only where all three risk parameters coincide. Such a finding would suggest a very different regulatory reaction than if contamination were found to occur in all environments within the region. Moreover, the regulator could then examine alternatives. Rather than a total ban, what would happen if happen if nitrogen applications were cut in half in high risk area? What could happen if different crops were grown?

The development of this integrated information and decision-management system would allow the development of logical regulatory structures. If public concern results in pressures to restrict or eliminate a particular chemical or nutrient, such an EGRET system would provide information necessary to identify those areas at risk of contamination. A particular agricultural chemical may be more benign in some environments and more hazardous in others. This information system would provide the basis for logical regulatory flexibility based on environmental and actual risk parameters, as an alternative to blanket actions that do not account for the variations in susceptibility that exist in the real world. As it stands now, a blanket elimination might eliminate an that was relatively benign in specific environments and require its replacement with a more dangerous substance, quite the opposite effect of everyone's good intentions.

The use of this information and decision-making systems will also make it possible to deal with the fact that natural resource boundaries and political boundaries rarely coincide. To rationally deal with actual groundwater contamination problems, it is necessary to deal with the hydrologic units of which the underground aquifers are a part. At the same time, to actually get programs coordinated and implemented it will be necessary to keep track of political decision-making boundaries. The proposed system would allow managers to overlay both natural resource and political boundaries, so that a rational program

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is developed to deal with the technical issues while identifying the political and administrative structures that will have to be coordinated in the administration of the program.

2. Anticipating Problems Areas and Establishing Priorities

Some may criticize this EGRET system on the basis that it assumes that we already have the data and the necessary models to create the system, when in fact there is simply to much that is not known about the fate and transport of agrichemicals in the environment. It is true that there are profound gaps in the knowledge base, as has been discussed in this paper. There is a real need to support monitoring and research programs relevant to groundwater protection. Some things, however, are known. What is known can be used, or not. We should make best use of the information that we do have and adjust as we learn better. Existing models may be unable to combine all of available data and provide precise estimates, but the proposed system can use available heuristic thinking. For example, we do know that sandy soils, a shallow water table, and high precipitation will facilitate nitrate leaching, even if we do not know precise rate of transport or degradation of all nitrogen metabolites. In any case, development of such a system should quickly highlight weak links in current modeling efforts and the current state of knowledge of fate and transport of specific chemicals. This information, in turn, could assist in prioritizing the research agenda.

It is also true that as new knowledge becomes available, the vision of how the total system should be put together will change. However, if there is no *overarching* vision of how the whole system can be put together, then in the end we will be left with a complex mix of non-integrated programs. The design of the total system will have allow for growth and evolution, but there must be some agreed upon *blue-print* so that the components of the system can interact and grow together.

Ideally, a comprehensive EGRET system could be used to anticipate where agricultural and environmental problems were most likely to develop, and research priorities could be directed accordingly. Rather than reacting to environmental problems, the agencies would have a sophisticated capability to anticipate problem areas and plan accordingly. With this kind of anticipatory planning and program tracking system in place, the agencies would not only be able to immediately identify programs that are pertinent to issues of Congressional interest, but they would also be able to explain what they will need to do in the future, how much it will cost, and why it is necessary. Using this system, it would not be necessary for the agencies to go through a two-year start-up process to identify relevant programs and activities, each time the public and Congress focus on a new topic of concern.

Using the EGRET system, the agencies should be able to report to Congress a proposed 5-year, 10-year or 15-year plan to address critical issues, such as groundwater protection. Congress may wish to assess these plans, modify them as they see necessary, then work with the Administration to develop funding strategies to address the identified issue areas. Some programs receive steady funding so that long term analyses can be developed and implemented. Many projects, however, receive short-term funding that is inadequate to develop the sustained support for research and program development that will be necessary to develop comprehensive programs to protect the environment. At the least, Congress should be approving an interagency agenda to address ground water protection on the basis of a 5-year implementation plan.

3. FINDING A HOME AND A POWER BASE FOR COORDINATED PLANNING

The EGRET system being proposed is technically feasible, but some may feel that it is too *idyllic*, that it will never survive the political process. It will be difficult, as discussed earlier, to get past groundwater program coordination and begin interagency integration of groundwater protection programs. The greatest difficulty will be in integrating the funding mechanisms of the distinct agencies.

> In some governmental projects which cut across agencies, it is difficult to get joint agreement on funds reallocation from one agency to another. This is because Congress is influenced in its budgeting process by the size of last year's budget. Therefore, any reduction in an agency's funds reduces the likelihood of its getting more in the

> future. Since the agency is always aware of this fact, the integrator needs more than expert power to reallocate resources among agencies when new information demonstrates a need for reallocation. The accomplishment of organization goals requires greater integrator influence in decision making. The issue is how to increase the power of the integrator role.
>
> -- Jay Galbraith
> Designing Complex Organizations (1973)

It will be difficult, too, for Congress to work with integrated agency programs to address water quality. In 1987, Congressman Brown wrote a letter to the Speaker of the House, in which he noted that a number of committees would be holding groundwater protection hearings. Rather than each committee inviting the same set of witnesses in to repeat the same testimony, he suggested that the Speaker make the topic of groundwater a *leadership issue*. Joint hearings could be held, or the respective domains of each of the committees could be carefully defined. The point was that some mechanism needed to be developed to facilitate coordination among the Congressional committees that were seeking to increase coordination of the Federal agencies.

It is beyond the scope of this paper to resolve how Congress is going to develop coordinating mechanisms within its committees, so that it can support the development of integrated interagency programs to protect the environment. This will not be easy. The respective committees have a natural and keen interest in protecting the range of their jurisdictions. However, Congress can either work to develop solutions, or it will be itself part of the problem.

If development and implementation of an EGRET system is to happen, it will be necessary that a group be identified with specific authority and responsibility to make it happen. The process must be invested with substantial authority, since it will require coordinating across current lines of authority. If responsibilities for these new programs are invested in any one agency, other agencies are likely to resist and the whole intent of interagency program integration will be thwarted.

The development of the EGRET system could be given to an organization such as the Federal Coordinating Committee on Science and Engineering Technology (FCCSET). However, this particular institution has served more to coordinate and report on Federal agency activities than in the resolution of power conflicts or development of new programs. FCCSET also lacks the institutional structure to monitor and incorporate State and local activities. The Council on Environmental Quality (CEQ) and the Office of Science and Technology (OSTP) are alternative homes for EGRET. However, both would have to expand and develop their administrative infrastructure.

EGRET could also be housed at the Office of Management and Budget. While this approach might be appealing in that it would provide the coordinating role of the group with a formidable stick and a considerable carrot, most OMB deliberations must be conducted behind closed doors, which would hinder public airing and resolution of questions about national priorities.

The next option would be to create a new Federal agency or council that responds directly to the President. The coordinating council would need access to such a major power source, so as to resolve conflicts of authority between departments. A permanent "Interagency Commission for Departmental Coordination of Environmental Issues" could be established, reporting directly to the President. The commission should be imbued with necessary authority and with the characteristics of a lateral coordinating body as were discussed in the course of this article. The proceedings and progress of this commission be subject to continued Congressional review. The White House is a logical power source, but the President must be committed to the program or the whole effort is pointless. For this approach to work, the President must want it to work. If the President in uninterested or hostile, such as was the case with the old Water Board and has been in the past with the Council on Environmental Quality, the capabilities and utility of the council will dwindle and fade.

Alternatively, Congress could provide the needed oversight through the use of Congressional Committees or the creation of a unique review board. Participation by Congressional members on boards to review environmental policy is not a unique concept. For example, Congressional members serve as part of the board of directors of the Environment and Energy Studies Institute.

The point in listing these various options for housing EGRET, is simply that the development of such a comprehensive and integrated management system, will require a secure power base from which to coordinate and integrate the respective agency programs. The proposed system is new and innovative, the management of the system may have to be new and innovative as well.

IV. CLOSING COMMENTS

A. FINALLY ADDRESSING 'THE BIG PICTURE': THE DANDELION MODEL

Groundwater, as argued earlier, is an integral part of the hydrologic cycle, which is in turn an integral part of the global ecosystem. Efforts currently underway to protect surface waters, air quality, food safety, global climate and other environmental efforts will all be affected by what is done to protect water quality, and efforts in these other arenas will affect the quality of groundwater. On one hand, it is reasonable that programs should be developed to address specific issues individually in order to provide focus and direction to administrative programs, which are otherwise all to easily diverted and diluted. Addressing these programs individually keeps them relatively comprehensible and manageable. On the other hand, if programs to address environmental issues are not developed with some understanding of how they each address components of the larger ecosystem, then there is the high risk of redundant or even contradictory programs.

The need to create coordinated, integrated, intra-agency programs that address the whole array of relevant parameters is not relevant to the issue of groundwater protection alone. Most environmental and natural resource issues will require that Federal agencies develop capacities to organize flexibly and creatively to bring their vast and disparate organizational structures and resources to some coordinated focus in order to address complex problems that do not respect political boundaries or bureaucratic guidelines. In this article, suggestions have been made for facilitating coordination and communication between government agencies and to develop an integrated information and decision management system. These suggestions could be readily applied to other environmental issues. The entire information management system proposed for groundwater protection could itself serve as a module in a larger system to address global environmental issues as a whole.

As shown in Figure 59, each of the various environmental issues will need to:

- draw from an overlapping set of coordinated data bases,
- develop central clearinghouse or search capabilities,
- collect more data and prioritize developing research,
- enhance and develop modular models,
- integrate preceding activities into easily viewed geographic information systems,
- develop decision making systems to facilitate the management of the flood of data that will be involved,
- coordinate and plan interaction with other programs areas to maximize the efficient use of scarce resources and to avoid contradictory efforts. There will be a tedious waste of *start-up* time and wasteful duplication of

efforts if similar information systems are set up independently for each issue of public concern.

The schematic shown in Figure 60 unexpectedly took on the form of a familiar plant, hence the name of this comprehensive global environment information and management system: 'The Dandelion Model'. It would be easy to push the analogy: the system is *rooted* in the *soil* of good data bases, from which information is extracted and transmitted up...but mercy - if not good-taste - will prevail. Global environmental issues are diverse and complex. It would take another paper or set of papers to develop the implications of this Dandelion Model. However, a preliminary discussion of the relation of groundwater resources to the global environment is provided in Appendix 16. An introduction to work already underway to address relevant portions of such a global environment system are also discussed.

B. DEALING WITH THE 'IMPOSSIBLE'

> *I don't pretend to understand the Universe - it's a great deal bigger than I am...People ought to be modester.*
> -- Thomas Carlyle
> Macmillan Dictionary of Quotations

> *My own suspicion is that the universe is not only queerer than we suppose, but queerer than we can suppose.*
> -- J. B. S. Haldane
> Possible Worlds

A legitimate argument against a global model, or any model, is that it implies that we know a good deal more than we do. Models dealing with the global environment are particularly fraught with extrapolation and dubious assumptions. Such models should never be presented as having the *final word* on any subject. If properly used, however, the development of comprehensive models can force integration of currently available knowledge and make it starkly clear where information is lacking on how the system functions as a whole. In this light, such a global system would make it possible to coordinate and prioritize developing efforts in all fields, while providing managers a way of keeping track of the myriad efforts that are being developed. As well, such as system would provide to decision-makers the best *guess-timates* that are currently available.

A related criticism is that such a grand design fails to take into account some very substantial gaps in the current information system:

> So when you hear that the answer to agrichemical contamination of groundwater lies in a future with each farmer's personal computer programmed to offer a precise prescription for pesticide use, think of reality and the fact that some U.S. counties still lack soil surveys (Smith, 1989).

There are fundamental gaps in basic research and data collection. However, the development of this global systems approach could be used to identify and prioritize data collection and research efforts, so that the critical missing links are identified and addressed.

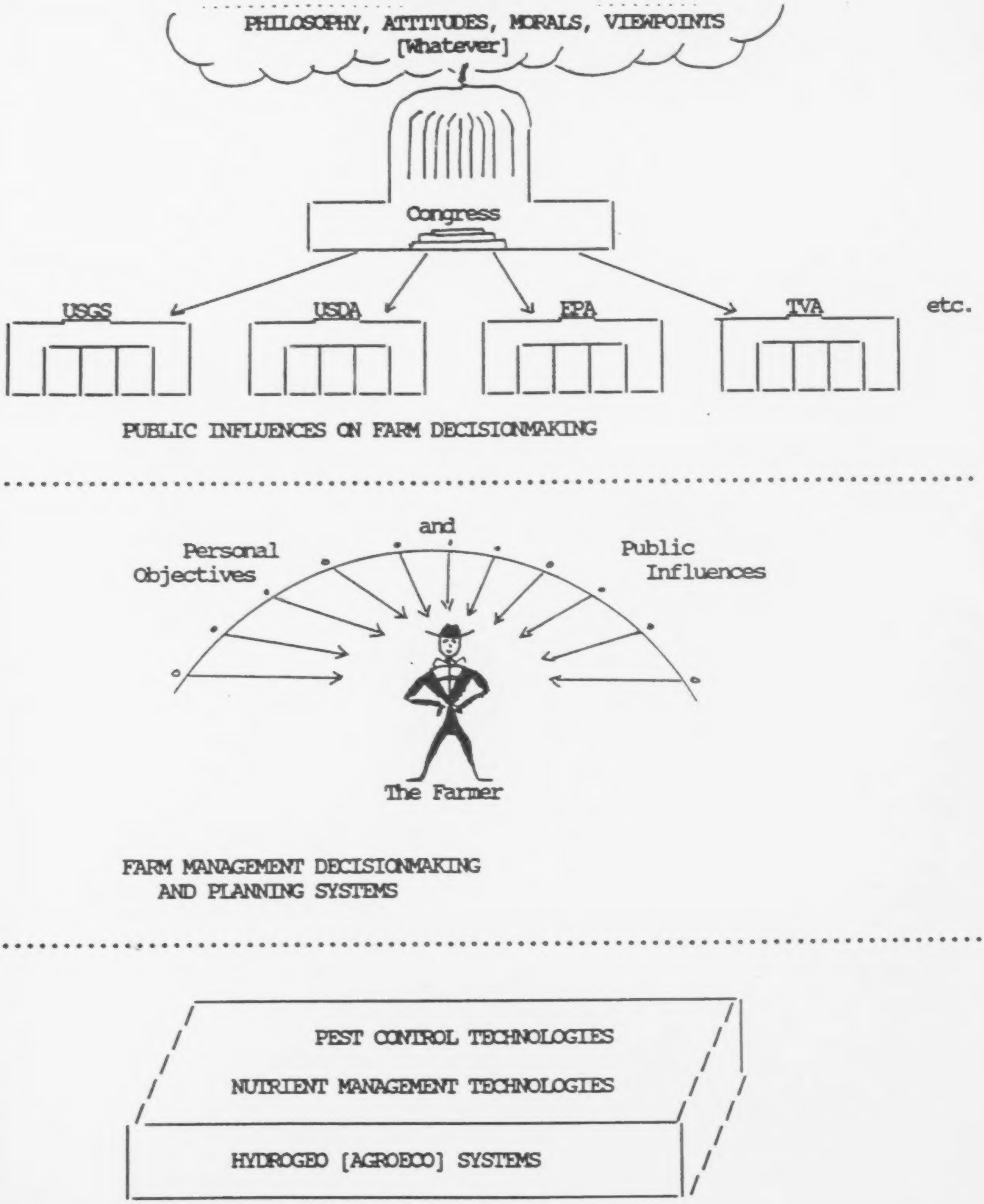
Another argument against the development of such a system is that it is simply too complex and difficult. The point, however, is that all of the components of a global systems are being developed anyway, as discussed in Appendices 13 - 17. The only real question is whether the many components that are being developed will be crafted in such a way that the resources of all of these efforts can be harnessed and utilized. At this time, it is more likely that a considerable amount of money will be spent on the parts, without the development of any comprehensive system with which to put the parts together.

In the meantime, the development of such a grand design as the Dandelion Model of the global environment cannot be used as an excuse for not doing anything now. As has been discussed throughout this paper, there are a number of steps that can and should be taken now to protect groundwater from any harmful agricultural production practices. While these efforts are underway, however, it is time to begin to working on **'The Big Picture'**.

> *One is always reading that the sorts of drastic changes proposed here are infeasible, impractical, and unrealistic, particularly in the economic and political sense. I believe that the alternative of proceeding along our present course is physically impractical as well as socially unacceptable. Can our political and economic scientists devise ways to bring the world's institutions in line with physical reality in time?*
>
> -- John P. Holdren
> Energy and Resource Program
> Univ. of California, Berkeley (1975)

V. FIGURES

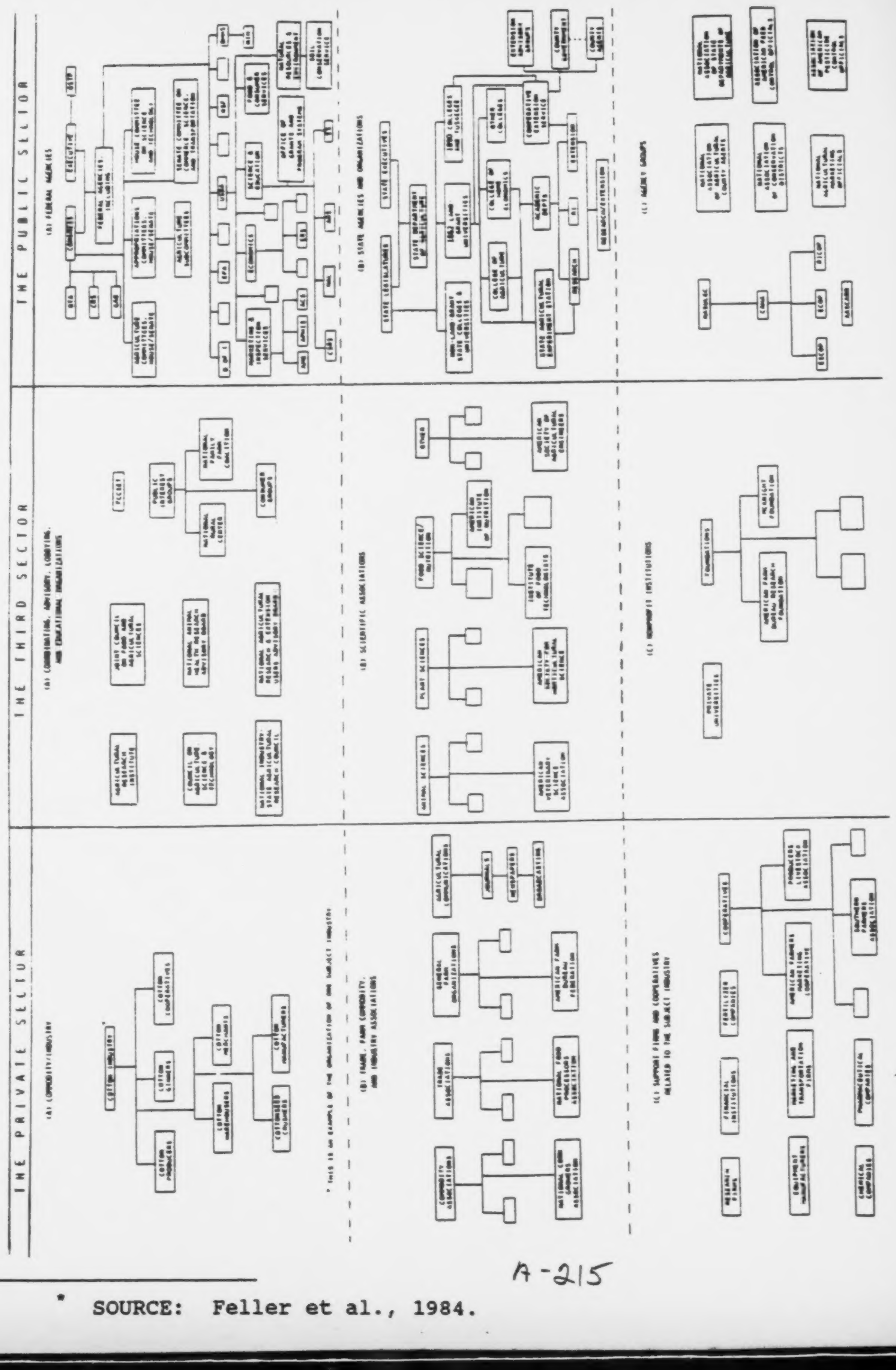
Figure 1. Roles of Federal agencies in addressing groundwater issues*.


PHILOSOPHY, ATTITUDES, MORALS, VIEWPOINTS
[Whatever]
Congress
USGS
USDA
EPA
TVA
etc.
PUBLIC INFLUENCES ON FARM DECISIONMAKING
Personal Objectives
and
Public Influences
The Farmer
FARM MANAGEMENT DECISIONMAKING AND PLANNING SYSTEMS
PEST CONTROL TECHNOLOGIES
NUTRIENT MANAGEMENT TECHNOLOGIES
HYDROGEO [AGROECO] SYSTEMS

---

* SOURCE: OTA, 1989.

Figure 2. A general guide to the sectors and types of organizations involved in the agricultural research and technology transfer system[*].


THE PUBLIC SECTOR
THE THIRD SECTOR
THE PRIVATE SECTOR

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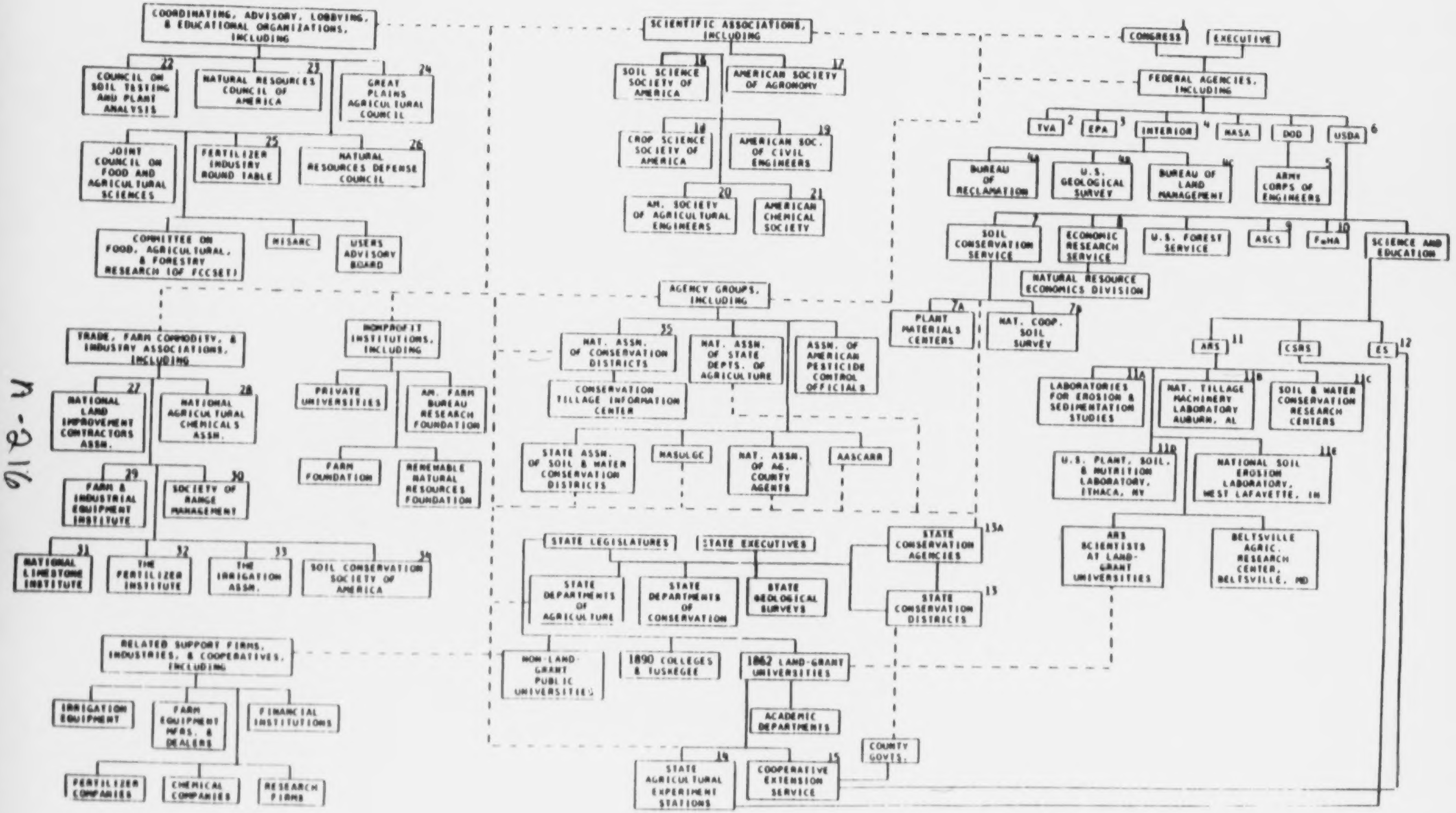
[*] SOURCE: Feller et al., 1984.

Figure 3. Relevant Organizations in Soil ... conservation*.


CONGRESS 1
EXECUTIVE
FEDERAL AGENCIES, INCLUDING
TVA 2
EPA 3
INTERIOR 4
NASA
DOD
USDA 6
BUREAU OF RECLAMATION 4A
U.S. GEOLOGICAL SURVEY 4B
BUREAU OF LAND MANAGEMENT 4C
ARMY CORPS OF ENGINEERS 5
SOIL CONSERVATION SERVICE 7
ECONOMIC RESEARCH SERVICE 8
NATURAL RESOURCE ECONOMICS DIVISION
U.S. FOREST SERVICE
ASCS 9
FmHA 10
SCIENCE AND EDUCATION
PLANT MATERIALS CENTERS 7A
NAT. COOP. SOIL SURVEY 7B
ARS 11
CSRS
ES 12
LABORATORIES FOR EROSION & SEDIMENTATION STUDIES 11A
NAT. TILLAGE MACHINERY LABORATORY AUBURN, AL 11B
SOIL & WATER CONSERVATION RESEARCH CENTERS 11C
U.S. PLANT, SOIL, & NUTRITION LABORATORY, ITHACA, NY 11D
NATIONAL SOIL EROSION LABORATORY, WEST LAFAYETTE, IN 11E
ARS SCIENTISTS AT LAND-GRANT UNIVERSITIES
BELTSVILLE AGRIC. RESEARCH CENTER, BELTSVILLE, MD
SCIENTIFIC ASSOCIATIONS, INCLUDING
SOIL SCIENCE SOCIETY OF AMERICA 16
AMERICAN SOCIETY OF AGRONOMY 17
CROP SCIENCE SOCIETY OF AMERICA 18
AMERICAN SOC. OF CIVIL ENGINEERS 19
AM. SOCIETY OF AGRICULTURAL ENGINEERS 20
AMERICAN CHEMICAL SOCIETY 21
AGENCY GROUPS, INCLUDING
NAT. ASSN. OF CONSERVATION DISTRICTS 35
NAT. ASSN. OF STATE DEPTS. OF AGRICULTURE
ASSN. OF AMERICAN PESTICIDE CONTROL OFFICIALS
CONSERVATION TILLAGE INFORMATION CENTER
STATE ASSN. OF SOIL & WATER CONSERVATION DISTRICTS
NASULGC
NAT. ASSN. OF AG. COUNTY AGENTS
AASCARR
STATE LEGISLATURES
STATE EXECUTIVES
STATE CONSERVATION AGENCIES 13A
STATE CONSERVATION DISTRICTS 13
STATE DEPARTMENTS OF AGRICULTURE
STATE DEPARTMENTS OF CONSERVATION
STATE GEOLOGICAL SURVEYS
NON-LAND-GRANT PUBLIC UNIVERSITIES
1890 COLLEGES & TUSKEGEE
1862 LAND-GRANT UNIVERSITIES
ACADEMIC DEPARTMENTS
COUNTY GOVTS.
STATE AGRICULTURAL EXPERIMENT STATIONS 14
COOPERATIVE EXTENSION SERVICE 15
COORDINATING, ADVISORY, LOBBYING, & EDUCATIONAL ORGANIZATIONS, INCLUDING
COUNCIL ON SOIL TESTING AND PLANT ANALYSIS 22
NATURAL RESOURCES COUNCIL OF AMERICA 23
GREAT PLAINS AGRICULTURAL COUNCIL 24
JOINT COUNCIL ON FOOD AND AGRICULTURAL SCIENCES
FERTILIZER INDUSTRY ROUND TABLE 25
NATURAL RESOURCES DEFENSE COUNCIL 26
COMMITTEE ON FOOD, AGRICULTURAL, & FORESTRY RESEARCH (OF FCCSET)
NISARC
USERS ADVISORY BOARD
NONPROFIT INSTITUTIONS, INCLUDING
PRIVATE UNIVERSITIES
AM. FARM BUREAU RESEARCH FOUNDATION
FARM FOUNDATION
RENEWABLE NATURAL RESOURCES FOUNDATION
TRADE, FARM COMMODITY, & INDUSTRY ASSOCIATIONS, INCLUDING
NATIONAL LAND IMPROVEMENT CONTRACTORS ASSN. 27
NATIONAL AGRICULTURAL CHEMICALS ASSN. 28
FARM & INDUSTRIAL EQUIPMENT INSTITUTE 29
SOCIETY OF RANGE MANAGEMENT 30
NATIONAL LIMESTONE INSTITUTE 31
THE FERTILIZER INSTITUTE 32
THE IRRIGATION ASSN. 33
SOIL CONSERVATION SOCIETY OF AMERICA 34
RELATED SUPPORT FIRMS, INDUSTRIES, & COOPERATIVES, INCLUDING
IRRIGATION EQUIPMENT
FARM EQUIPMENT MFRS. & DEALERS
FINANCIAL INSTITUTIONS
FERTILIZER COMPANIES
CHEMICAL COMPANIES
RESEARCH FIRMS

---

* SOURCE: Feller et al., 1984.

Figure 4. Organizational chart of selected Federal agencies with groundwater programs.

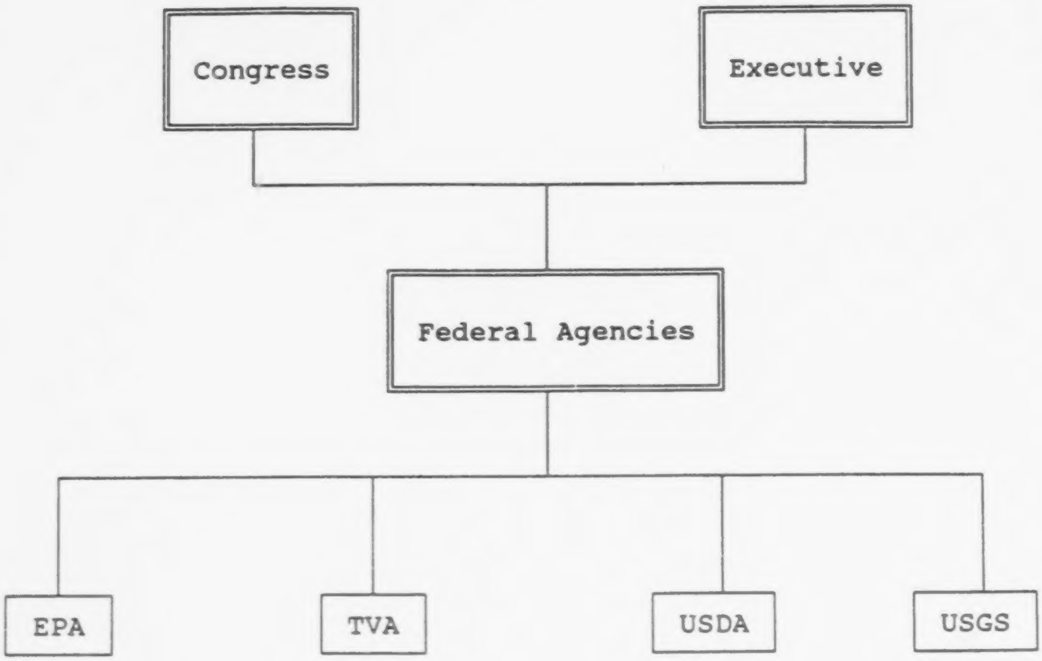
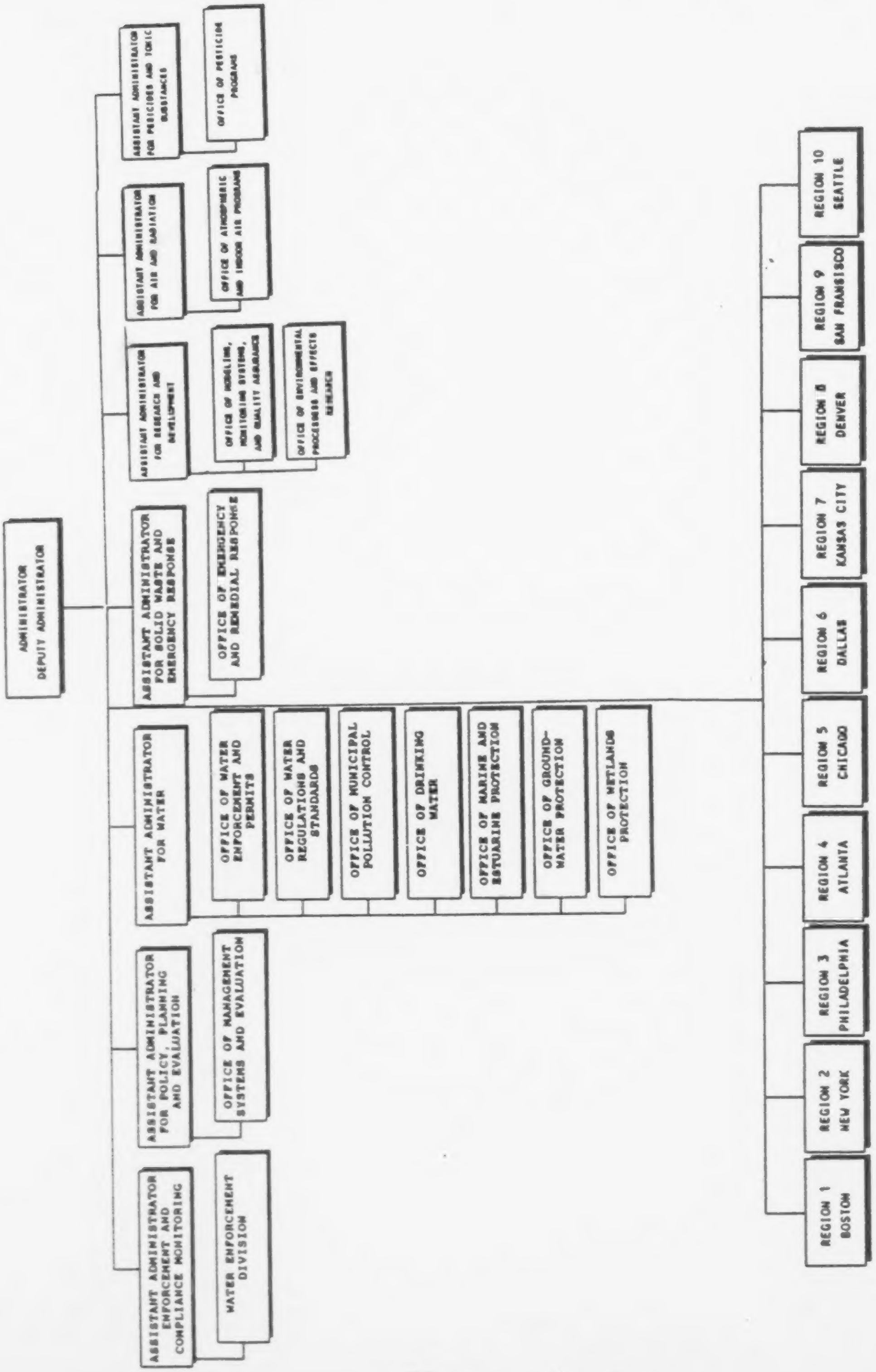

Congress
Executive
Federal Agencies
EPA
TVA
USDA
USGS

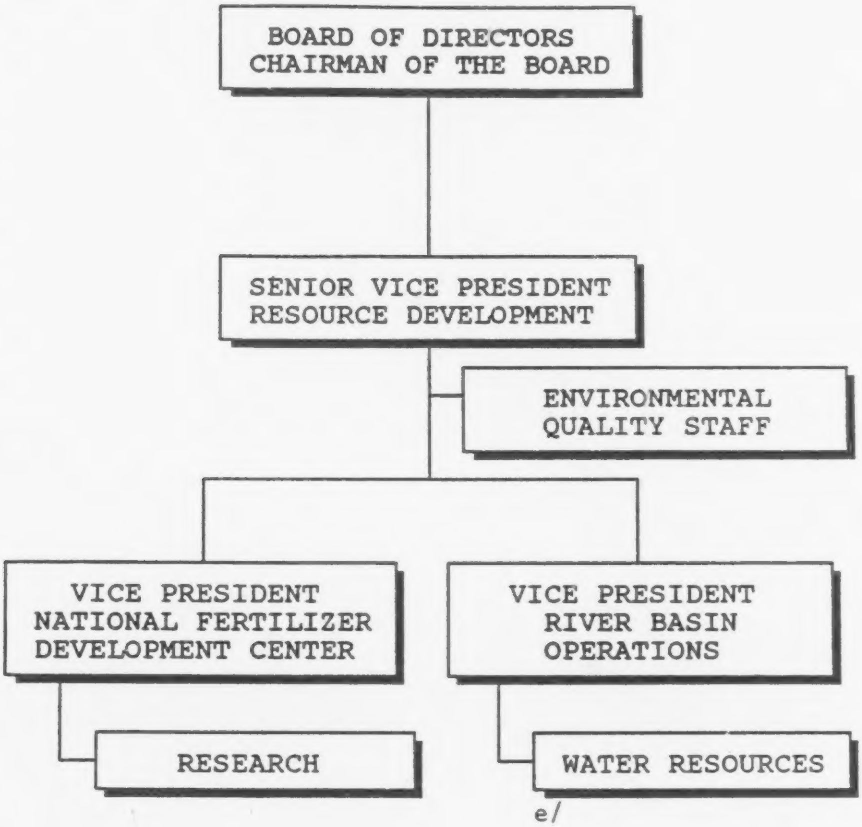
Figure 5. Organizational chart of offices with groundwater programs at the Environmental Protection Agency.


ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSISTANT ADMINISTRATOR ENFORCEMENT AND COMPLIANCE MONITORING
WATER ENFORCEMENT DIVISION
ASSISTANT ADMINISTRATOR FOR POLICY, PLANNING AND EVALUATION
OFFICE OF MANAGEMENT SYSTEMS AND EVALUATION
ASSISTANT ADMINISTRATOR FOR WATER
OFFICE OF WATER ENFORCEMENT AND PERMITS
OFFICE OF WATER REGULATIONS AND STANDARDS
OFFICE OF MUNICIPAL POLLUTION CONTROL
OFFICE OF DRINKING WATER
OFFICE OF MARINE AND ESTUARINE PROTECTION
OFFICE OF GROUND-WATER PROTECTION
OFFICE OF WETLANDS PROTECTION
ASSISTANT ADMINISTRATOR FOR SOLID WASTE AND EMERGENCY RESPONSE
OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
OFFICE OF MODELING, MONITORING SYSTEMS, AND QUALITY ASSURANCE
OFFICE OF ENVIRONMENTAL PROCESSES AND EFFECTS RESEARCH
ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION
OFFICE OF ATMOSPHERIC AND INDOOR AIR PROGRAMS
ASSISTANT ADMINISTRATOR FOR PESTICIDES AND TOXIC SUBSTANCES
OFFICE OF PESTICIDE PROGRAMS
REGION 1 BOSTON
REGION 2 NEW YORK
REGION 3 PHILADELPHIA
REGION 4 ATLANTA
REGION 5 CHICAGO
REGION 6 DALLAS
REGION 7 KANSAS CITY
REGION 8 DENVER
REGION 9 SAN FRANSISCO
REGION 10 SEATTLE

A-218

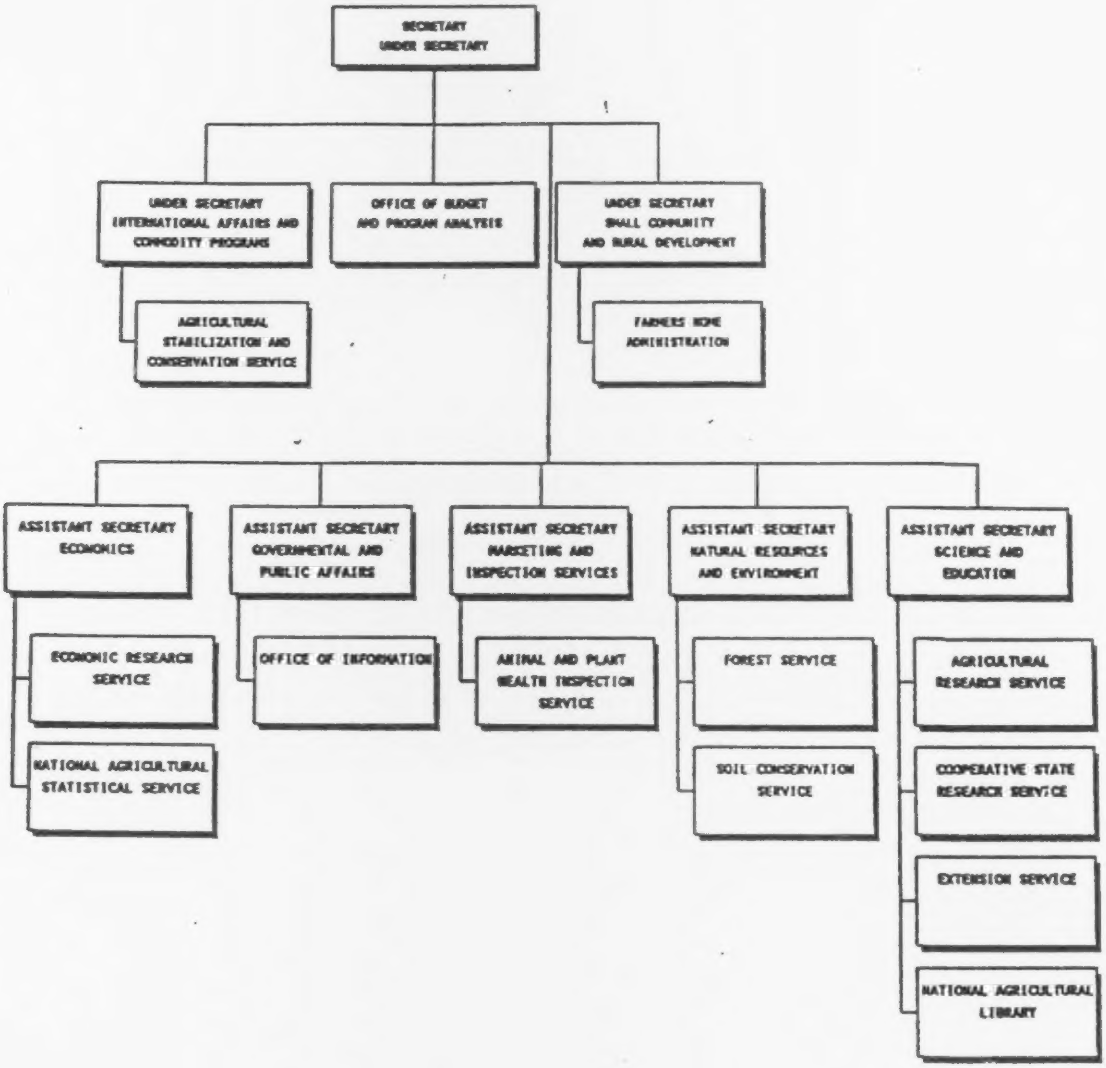
>>> DR FT <<<

Figure 6. Organizational chart of offices with groundwater programs at the Tennessee Valley Authority.


BOARD OF DIRECTORS
CHAIRMAN OF THE BOARD
SENIOR VICE PRESIDENT
RESOURCE DEVELOPMENT
ENVIRONMENTAL
QUALITY STAFF
VICE PRESIDENT
NATIONAL FERTILIZER
DEVELOPMENT CENTER
VICE PRESIDENT
RIVER BASIN
OPERATIONS
RESEARCH
WATER RESOURCES
e/

e/ All Water Quality Personnel for River Basin Operations are located in the Water Resources Division of the Natural Resources Division.

Figure 7. Organizational chart of offices with groundwater programs at the United States Department of Agriculture.


SECRETARY
UNDER SECRETARY
UNDER SECRETARY INTERNATIONAL AFFAIRS AND COMMODITY PROGRAMS
OFFICE OF BUDGET AND PROGRAM ANALYSIS
UNDER SECRETARY SMALL COMMUNITY AND RURAL DEVELOPMENT
AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE
FARMERS HOME ADMINISTRATION
ASSISTANT SECRETARY ECONOMICS
ASSISTANT SECRETARY GOVERNMENTAL AND PUBLIC AFFAIRS
ASSISTANT SECRETARY MARKETING AND INSPECTION SERVICES
ASSISTANT SECRETARY NATURAL RESOURCES AND ENVIRONMENT
ASSISTANT SECRETARY SCIENCE AND EDUCATION
ECONOMIC RESEARCH SERVICE
NATIONAL AGRICULTURAL STATISTICAL SERVICE
OFFICE OF INFORMATION
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
FOREST SERVICE
SOIL CONSERVATION SERVICE
AGRICULTURAL RESEARCH SERVICE
COOPERATIVE STATE RESEARCH SERVICE
EXTENSION SERVICE
NATIONAL AGRICULTURAL LIBRARY

>>> D <<<

Figure 8. Organizational chart of offices with groundwater programs at the United States Department of Interior.

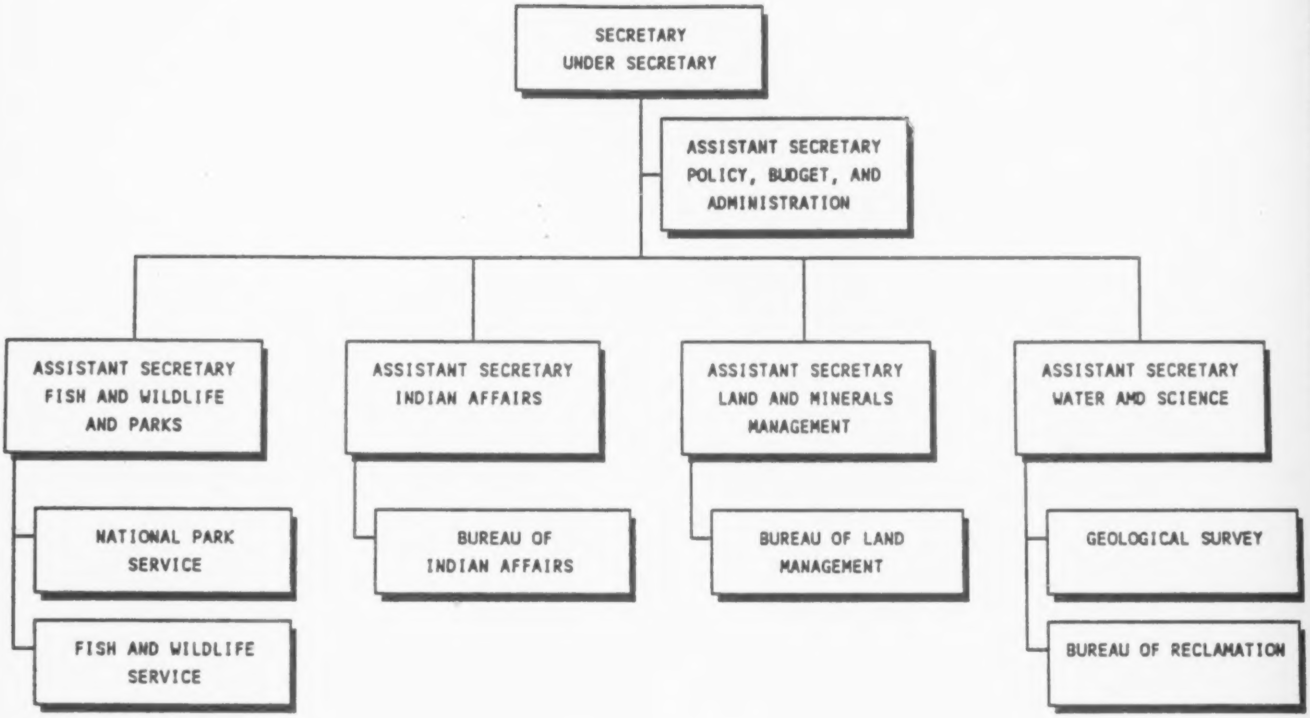
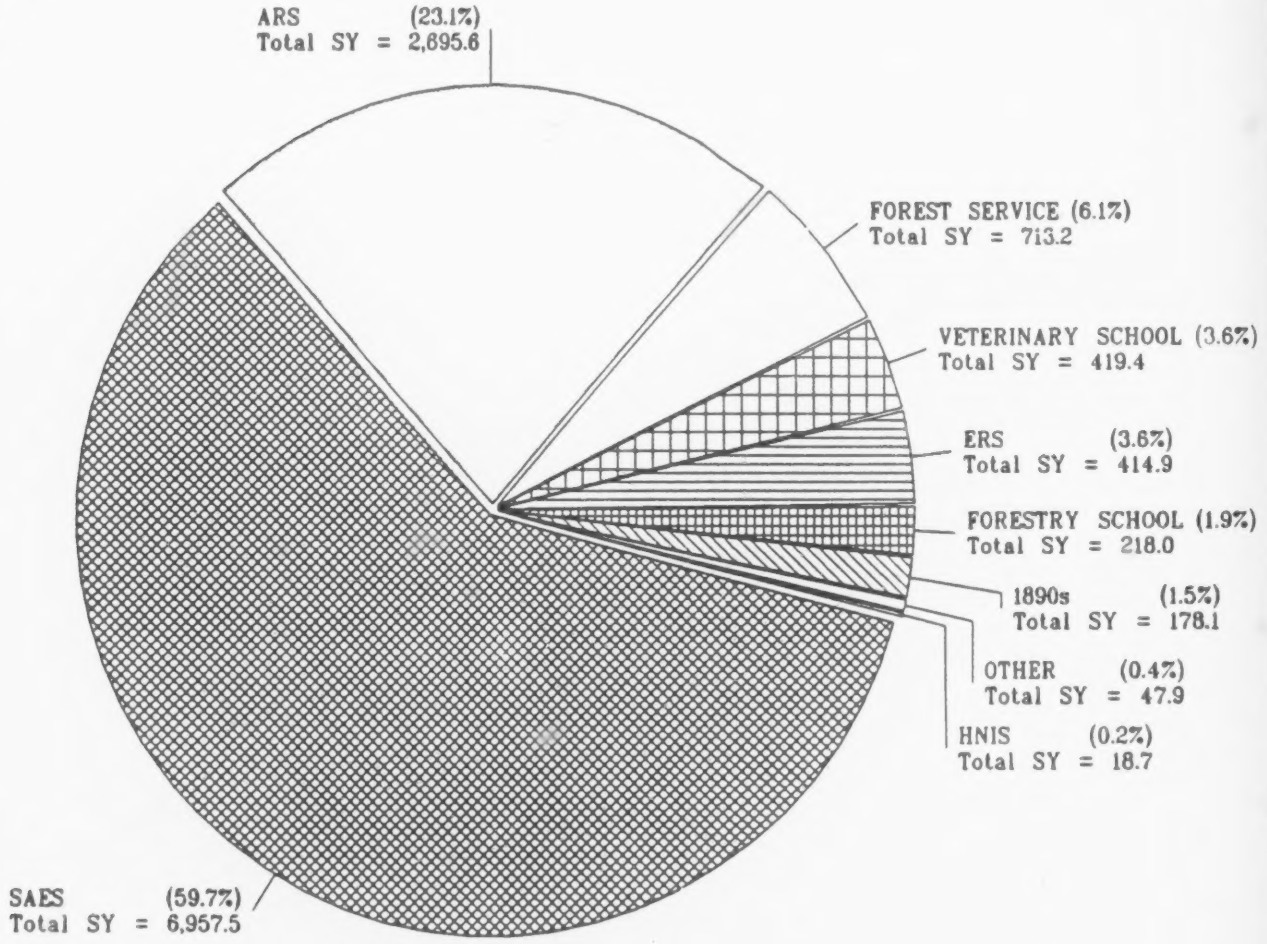

SECRETARY
UNDER SECRETARY
ASSISTANT SECRETARY POLICY, BUDGET, AND ADMINISTRATION
ASSISTANT SECRETARY FISH AND WILDLIFE AND PARKS
ASSISTANT SECRETARY INDIAN AFFAIRS
ASSISTANT SECRETARY LAND AND MINERALS MANAGEMENT
ASSISTANT SECRETARY WATER AND SCIENCE
NATIONAL PARK SERVICE
FISH AND WILDLIFE SERVICE
BUREAU OF INDIAN AFFAIRS
BUREAU OF LAND MANAGEMENT
GEOLOGICAL SURVEY
BUREAU OF RECLAMATION

Figure 9. Public agricultural research capacity: Personnel commitments*.

Personnel Commitments (SYs) by SAES & Other State Instit./Univ.

Source: Inventory of Agricultural Research, Fiscal Year 1987

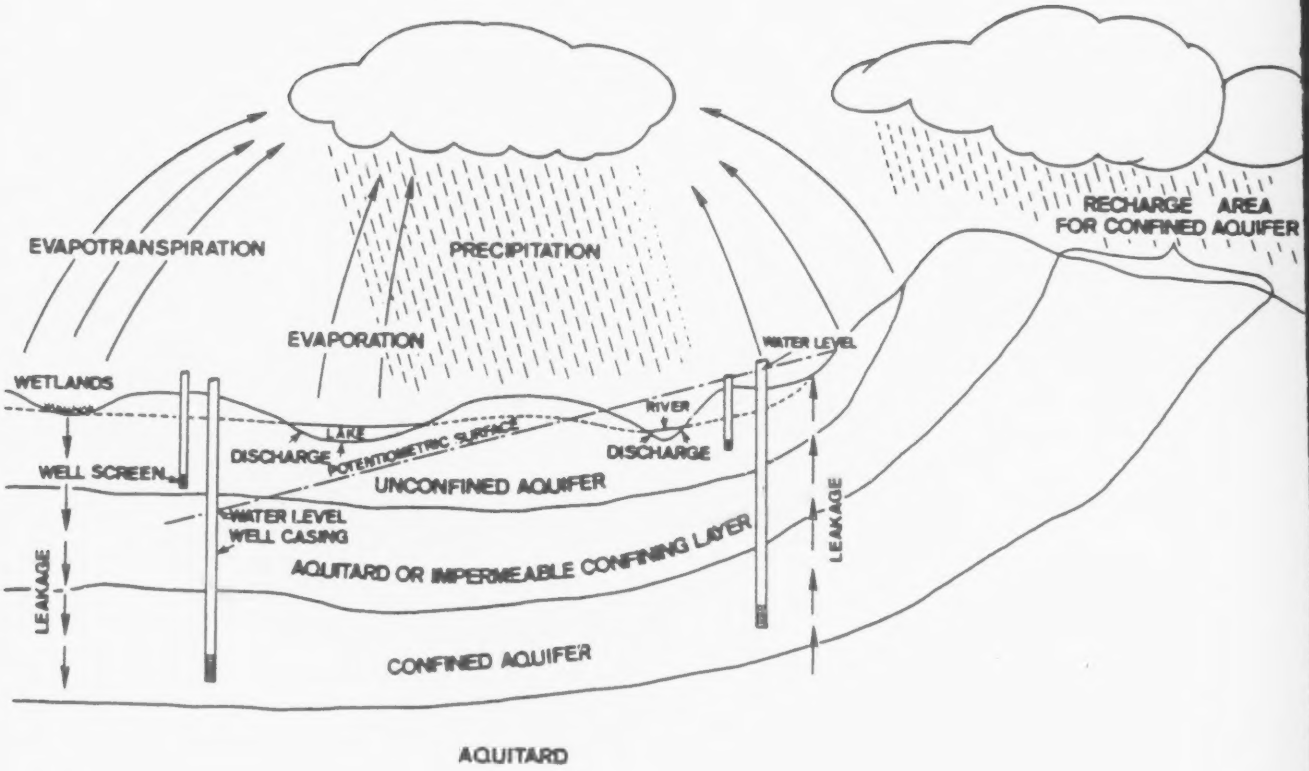


PUBLIC AGRICULTURAL RESEARCH SYSTEM
Total SYs = 11,677.4; $2,160,547,601

---

* SOURCE: Boyd, 1989.

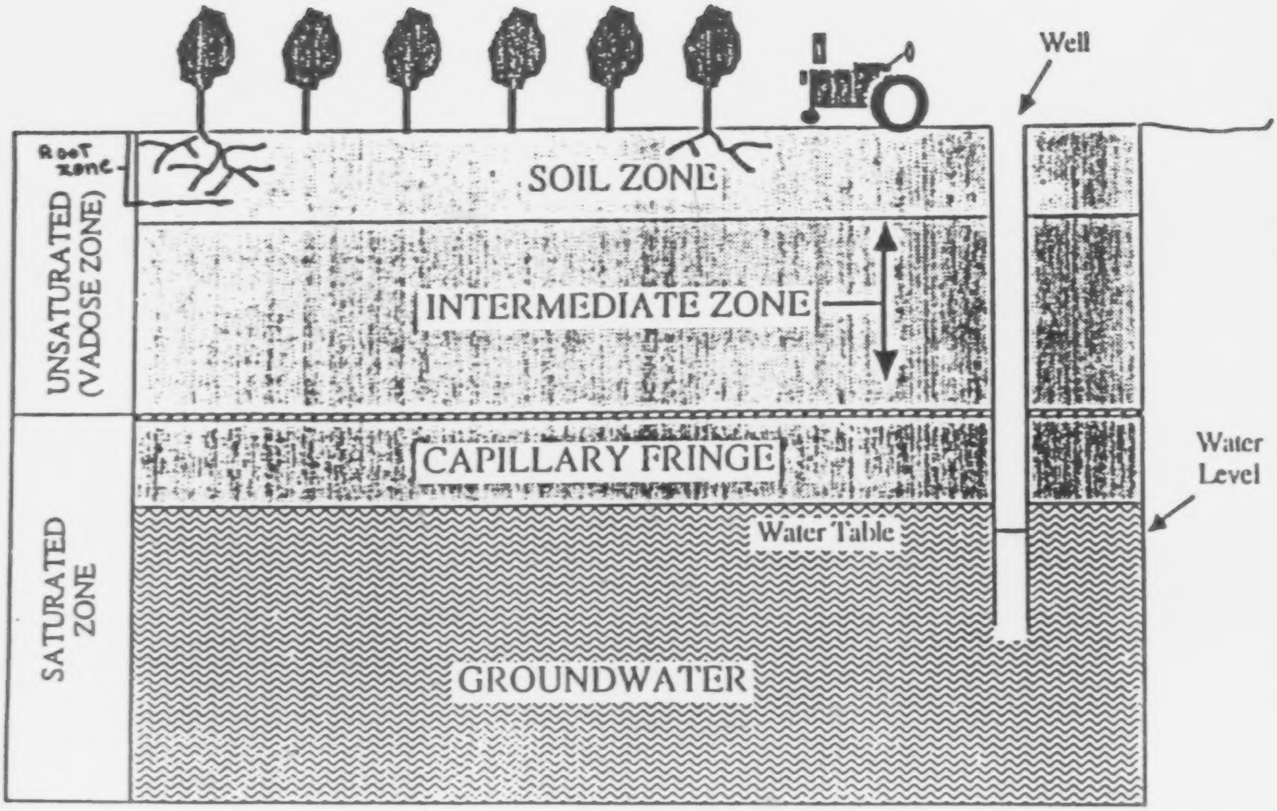
Figure 10. Relationships within the hydrologic system*.


EVAPOTRANSPIRATION
PRECIPITATION
RECHARGE AREA FOR CONFINED AQUIFER
EVAPORATION
WATER LEVEL
WETLANDS
RIVER
LAKE
DISCHARGE
POTENTIOMETRIC SURFACE
DISCHARGE
WELL SCREEN
UNCONFINED AQUIFER
WATER LEVEL
WELL CASING
AQUITARD OR IMPERMEABLE CONFINING LAYER
LEAKAGE
LEAKAGE
CONFINED AQUIFER
AQUITARD

---

[*] SOURCE: USEPA/OGWP, 1987, in Patrick, Ford and Quarles, 1987.

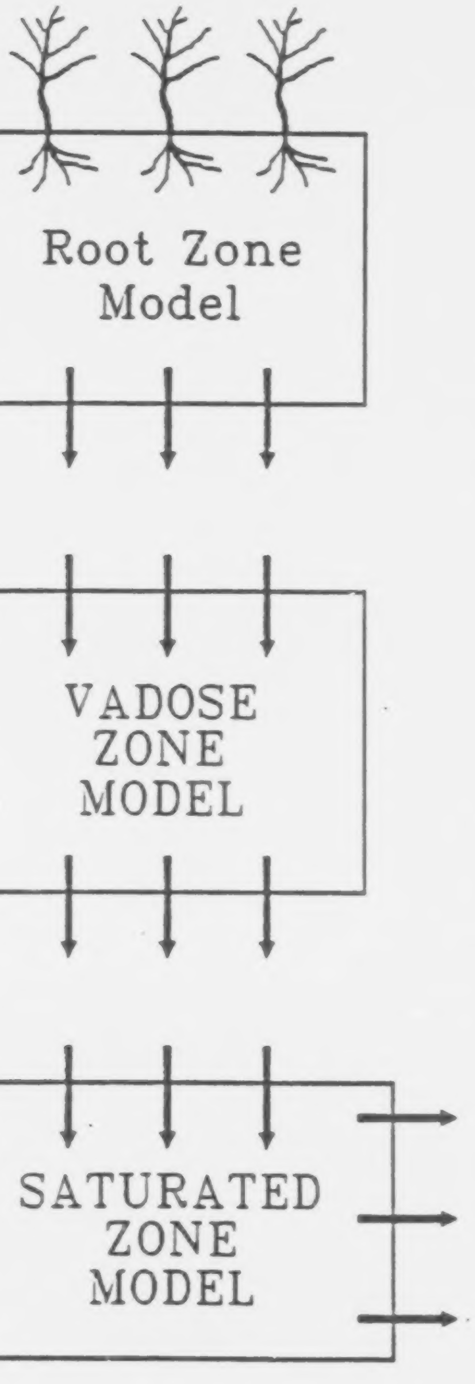
Figure 11. Zones of subsurface water*.


Well
ROOT ZONE
SOIL ZONE
UNSATURATED (VADOSE ZONE)
INTERMEDIATE ZONE
CAPILLARY FRINGE
Water Level
Water Table
SATURATED ZONE
GROUNDWATER

---

* SOURCE: USEPA/OGWP, 1987, in CEPPES.

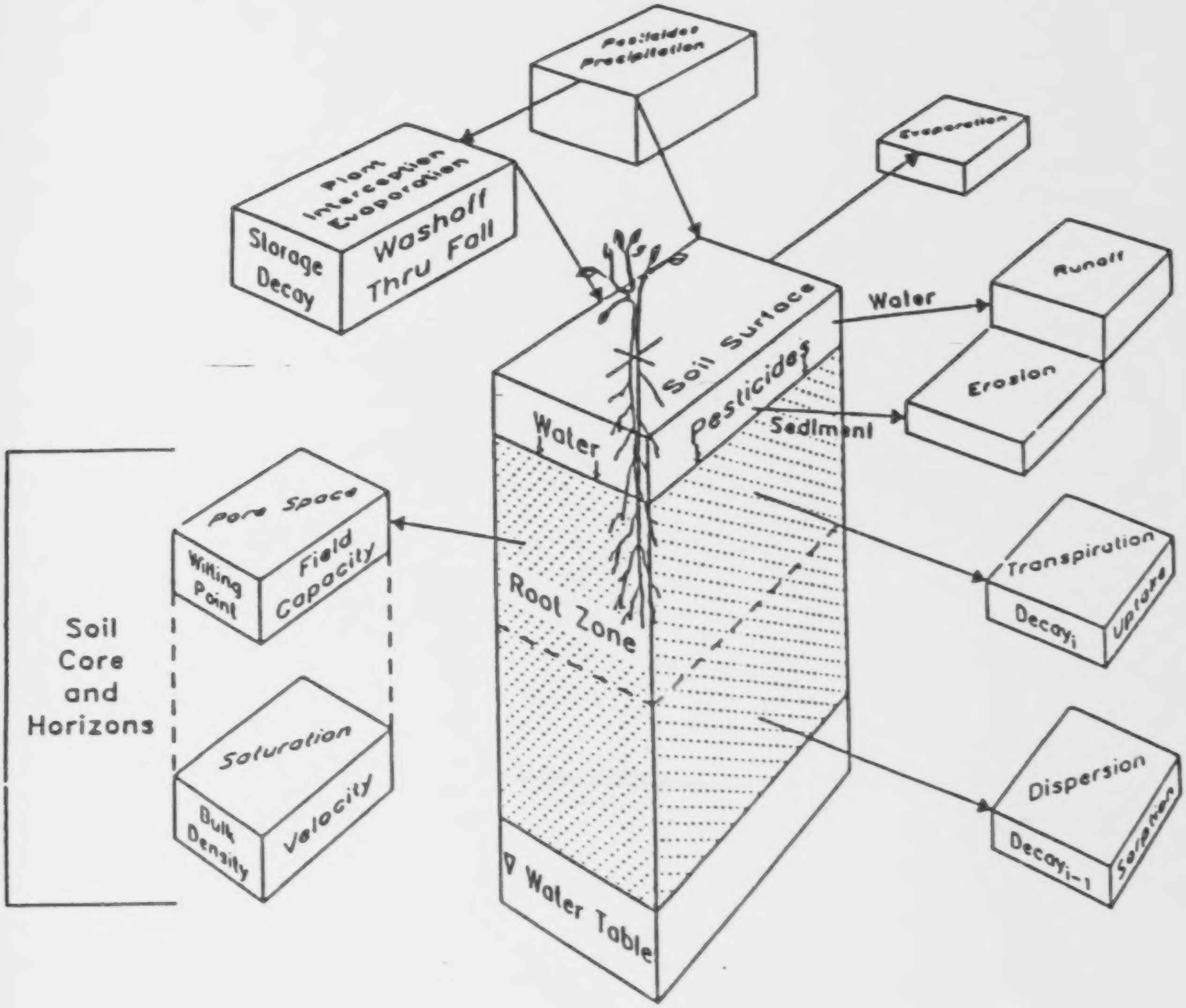
Figure 12. Zones in the soil profile[*].


Root Zone Model
VADOSE ZONE MODEL
SATURATED ZONE MODEL

---

[*] SOURCE: Dean and Carsel, 1988, in CEPPES.

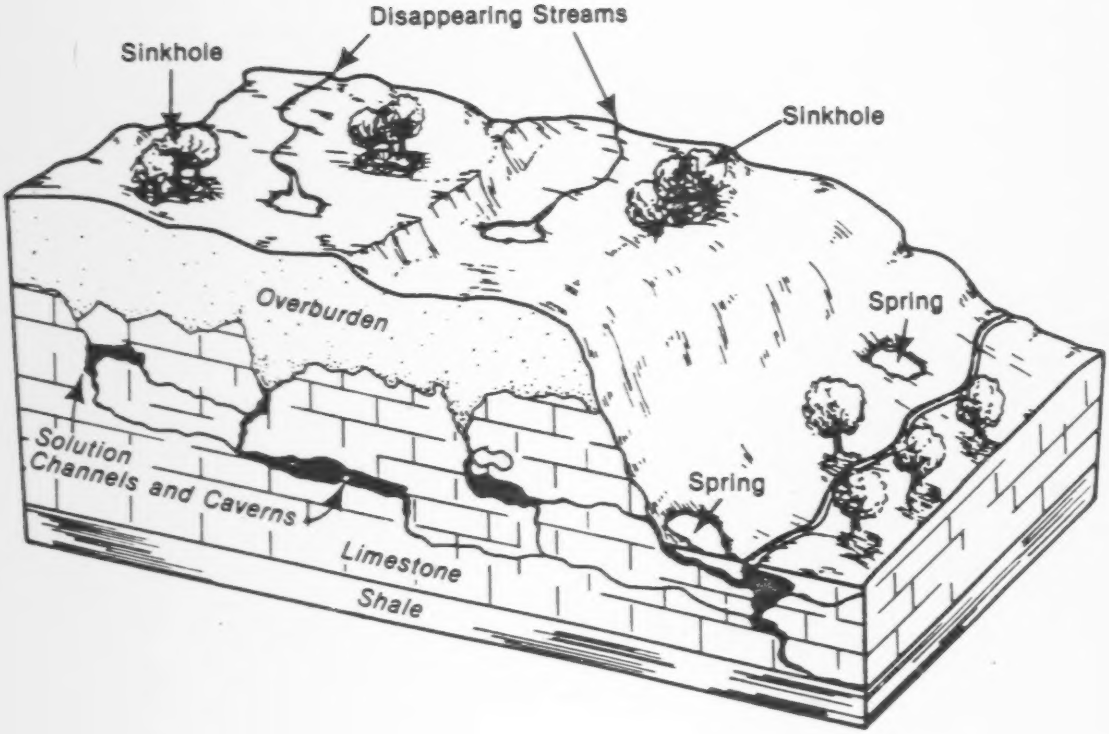
Figure 13. Pesticide root zone model of chemical and hydrologic functions*.


Pesticides Precipitation
Evaporation
Plant Interception Evaporation
Storage Decay
Washoff Thru Fall
Soil Surface
Pesticides
Water
Runoff
Erosion
Sediment
Water
Pore Space
Wilting Point
Field Capacity
Soil Core and Horizons
Root Zone
Transpiration
Decay$_i$
Uptake
Saturation
Bulk Density
Velocity
Dispersion
Decay$_{i-1}$
Sorption
∇ Water Table

---

[*] SOURCE: Carsel et al., 1984, in CEPPES.

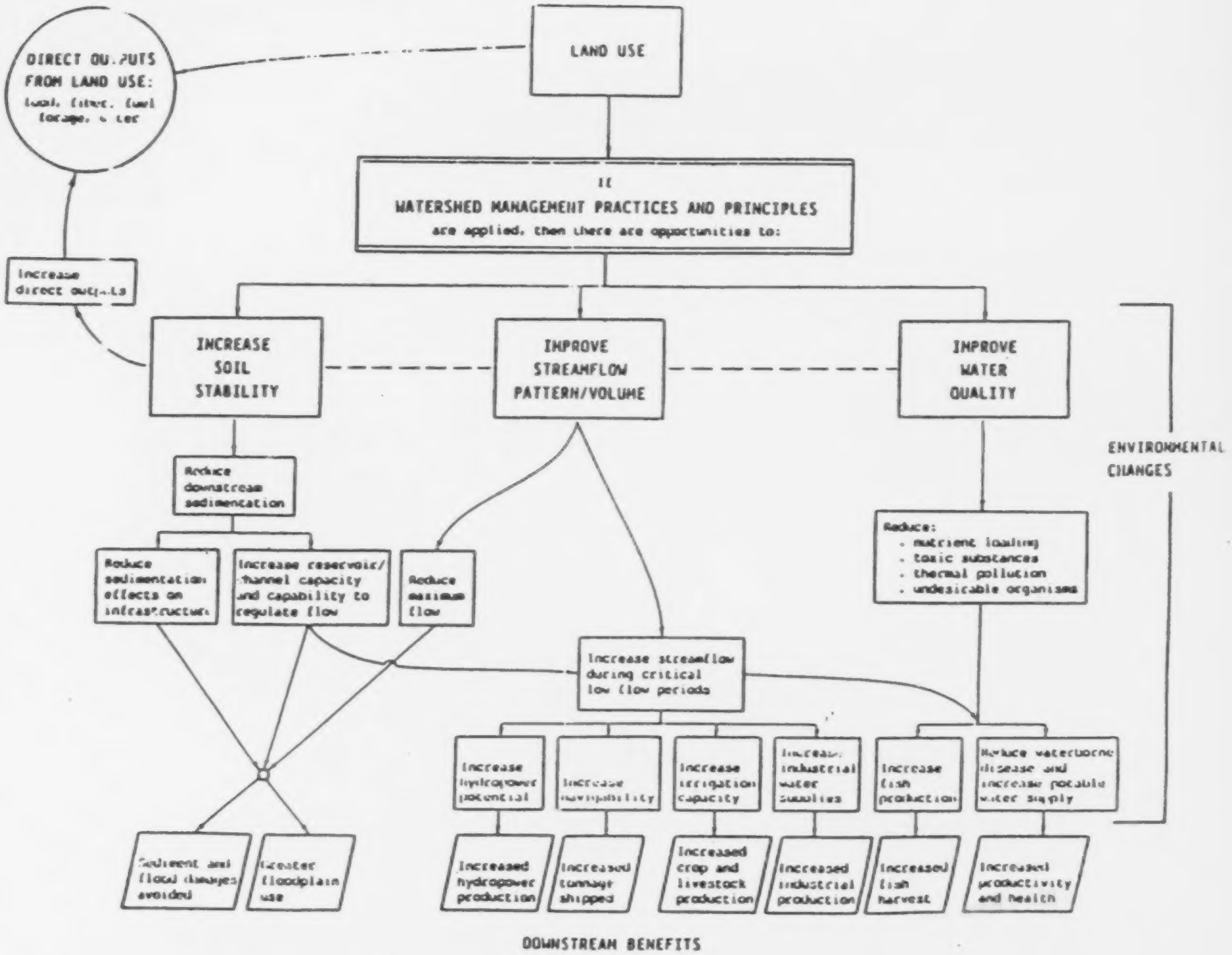
Figure 14. Karst topography*.


Disappearing Streams
Sinkhole
Sinkhole
Overburden
Spring
Solution Channels and Caverns
Spring
Limestone
Shale

---

* SOURCE: USDA/SCS, 1987b.

Figure 15. Groundwater protection as a component in watershed management*.


DIRECT OUTPUTS FROM LAND USE: food, fiber, fuel forage, water
LAND USE
If
WATERSHED MANAGEMENT PRACTICES AND PRINCIPLES
are applied, then there are opportunities to:
Increase direct outputs
INCREASE SOIL STABILITY
IMPROVE STREAMFLOW PATTERN/VOLUME
IMPROVE WATER QUALITY
ENVIRONMENTAL CHANGES
Reduce downstream sedimentation
Reduce sedimentation effects on infrastructure
Increase reservoir/channel capacity and capability to regulate flow
Reduce maximum flow
Reduce:
. nutrient loading
. toxic substances
. thermal pollution
. undesirable organisms
Increase streamflow during critical low flow periods
Increase hydropower potential
Increase navigability
Increase irrigation capacity
Increase industrial water supplies
Increase fish production
Reduce waterborne disease and increase potable water supply
Sediment and flood damages avoided
Greater floodplain use
Increased hydropower production
Increased tonnage shipped
Increased crop and livestock production
Increased industrial production
Increased fish harvest
Increased productivity and health
DOWNSTREAM BENEFITS

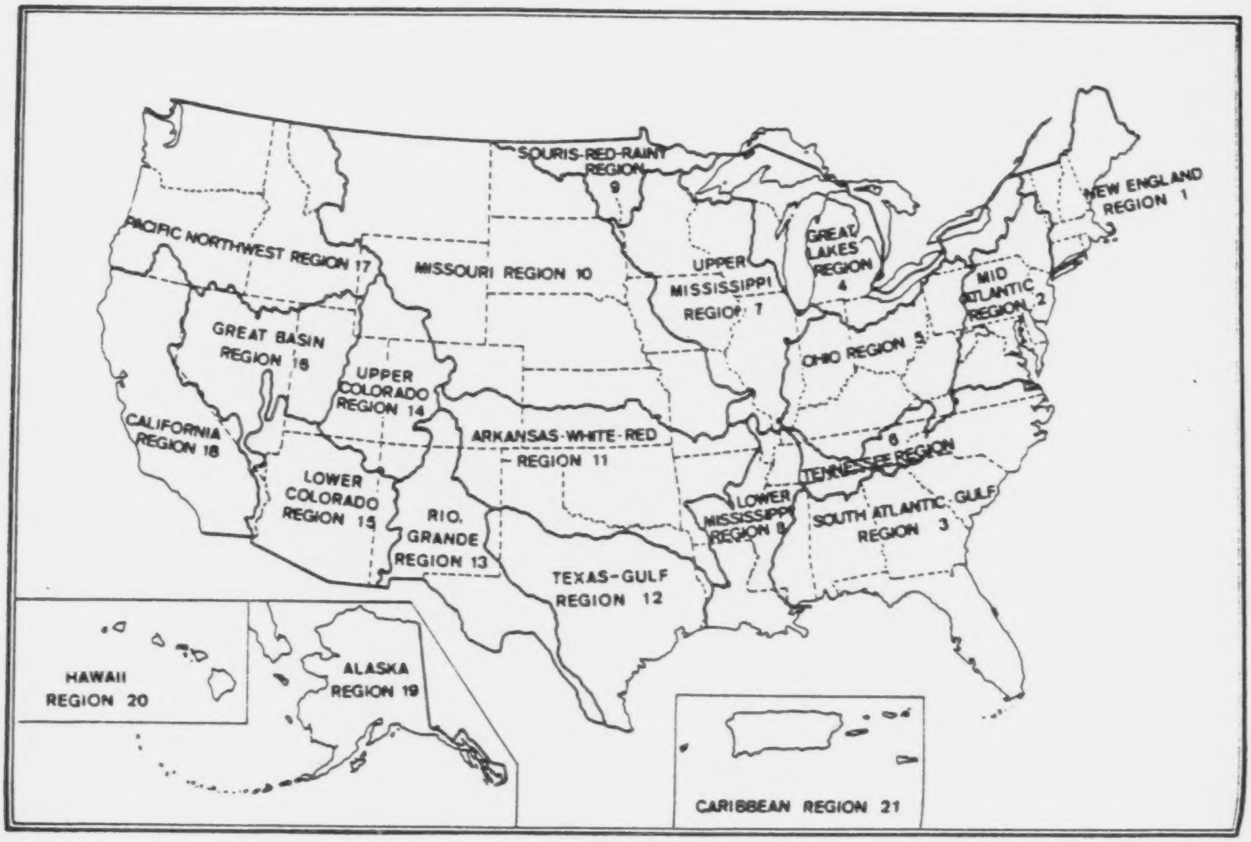
Environmental changes and downstream benefits from watershed management (modified from Gregersen, Brooks, Dixon, and Hamilton. 1987. Guidelines for the economic appraisal of watershed management projects. FAO Conservation Guide No. 16. FAO, me.

---

* SOURCE: Working Group on Watershed Management and Development, 1987.

A-228

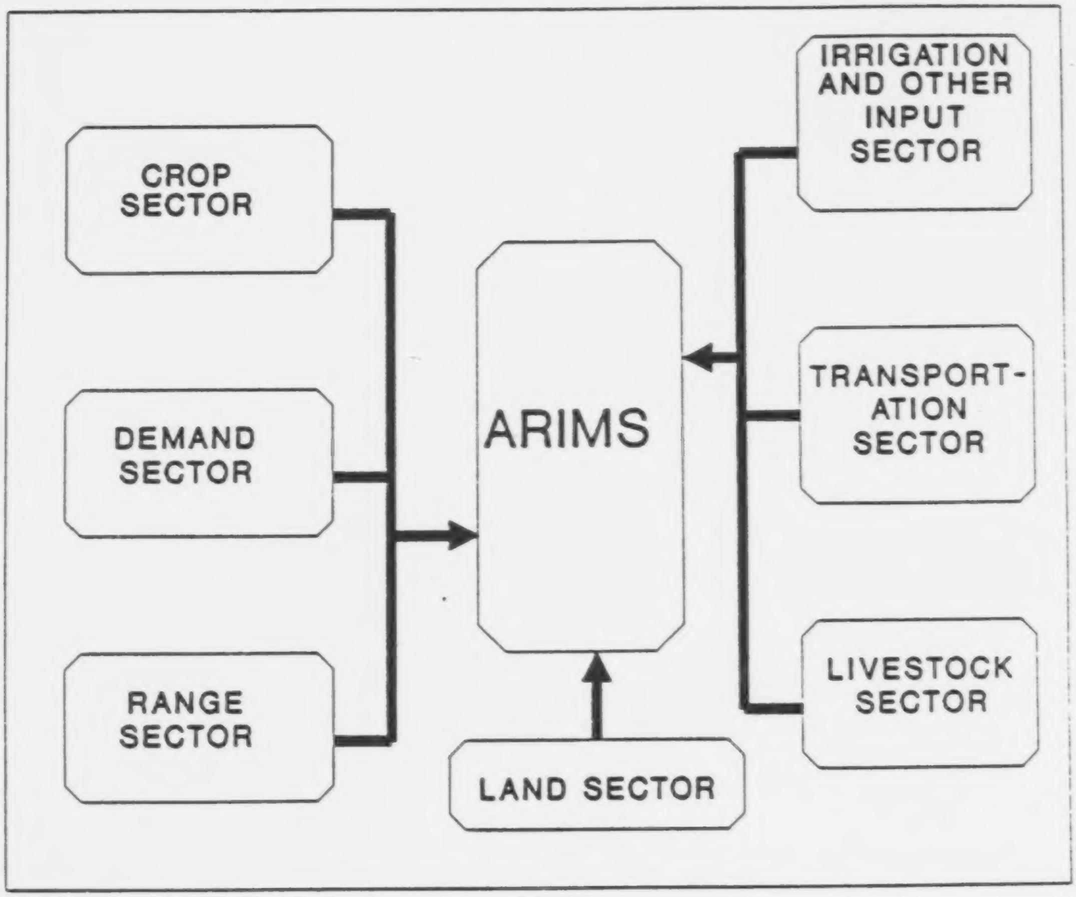
Figure 16. Water resource regions*.


SOURIS-RED-RAINY REGION 9
NEW ENGLAND REGION 1
PACIFIC NORTHWEST REGION 17
MISSOURI REGION 10
UPPER MISSISSIPPI REGION 7
GREAT LAKES REGION 4
MID ATLANTIC REGION 2
GREAT BASIN REGION 16
UPPER COLORADO REGION 14
OHIO REGION 5
CALIFORNIA REGION 18
ARKANSAS-WHITE-RED REGION 11
6 TENNESSEE REGION
LOWER COLORADO REGION 15
RIO GRANDE REGION 13
LOWER MISSISSIPPI REGION 8
SOUTH ATLANTIC-GULF REGION 3
TEXAS-GULF REGION 12
HAWAII REGION 20
ALASKA REGION 19
CARIBBEAN REGION 21

---

* SOURCE: U.S. Water Resources Council, 1978.

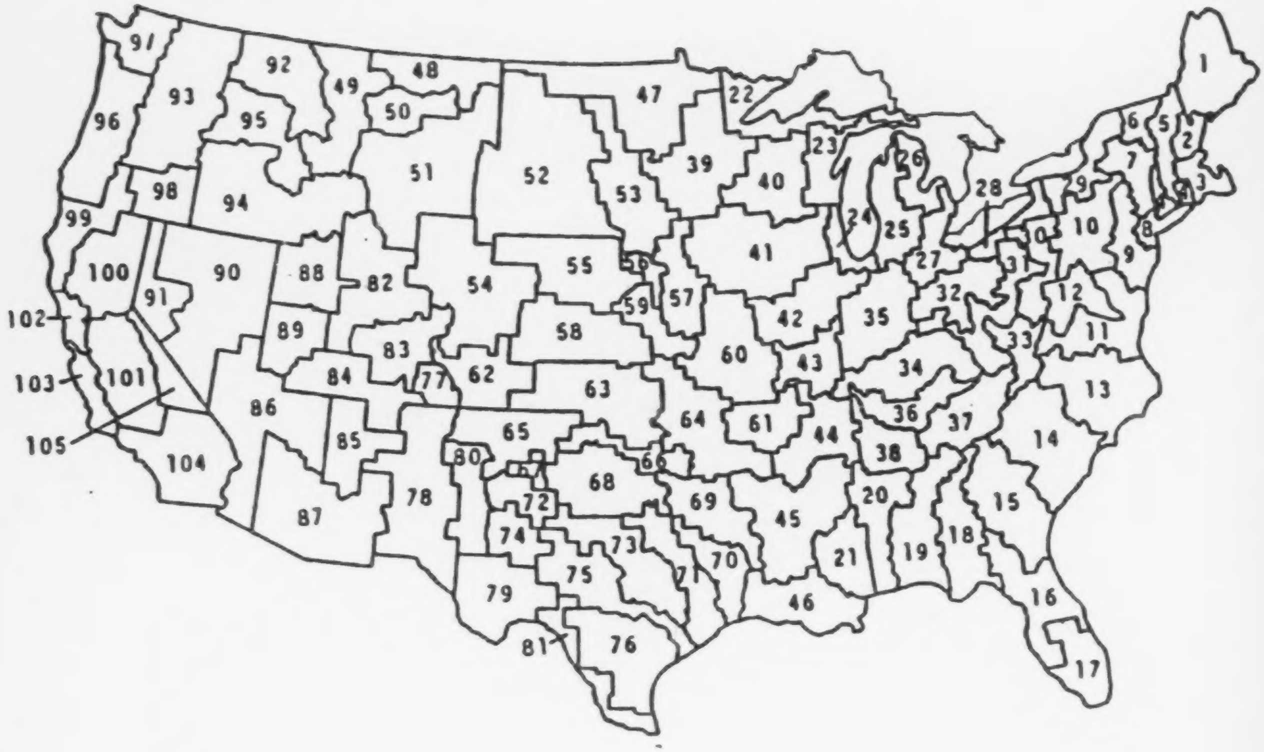
Figure 17. The national Agricultural Resource Interregional Modeling System used in the appraisal required by the Resources Conservation Act*.


CROP SECTOR
DEMAND SECTOR
RANGE SECTOR
ARIMS
LAND SECTOR
IRRIGATION AND OTHER INPUT SECTOR
TRANSPORTATION SECTOR
LIVESTOCK SECTOR

---

* SOURCE: CEPPES.

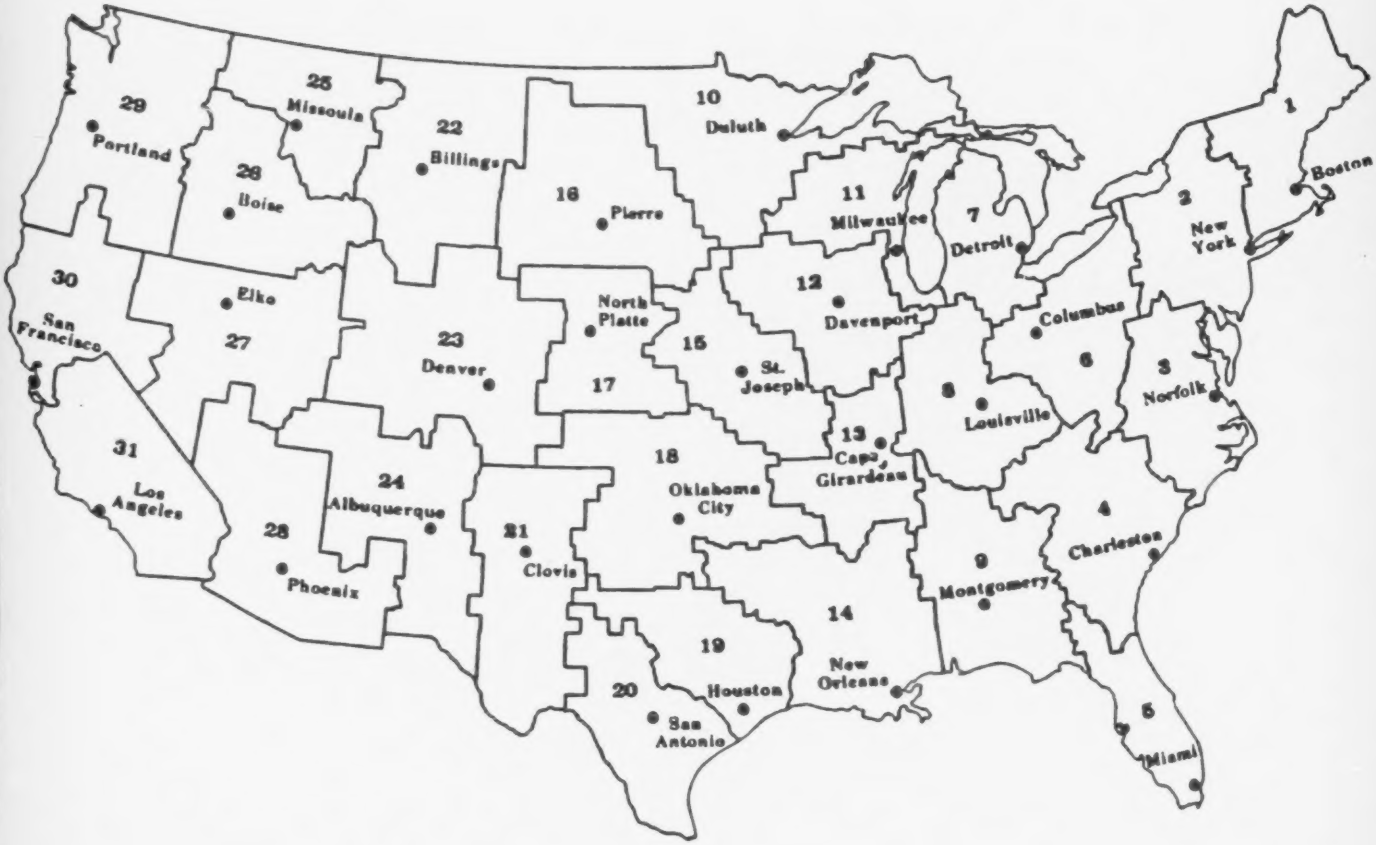
Figure 18. The 105 crop producing areas used in ARIMS*.


91
92
48
47
22
1
93
49
50
96
95
23
26
6
5
2
39
40
51
52
53
7
98
94
28
3
99
24
25
10
100
90
88
82
54
55
41
30
8
56
27
31
9
91
57
32
102
89
59
42
35
12
58
83
33
11
103
101
84
77
62
63
60
43
34
13
105
86
85
65
64
61
44
36
37
14
104
80
67
66
38
87
78
72
68
69
20
15
74
73
45
21
19
18
70
75
71
79
46
16
81
76
17

---

* SOURCE: CEPPES.

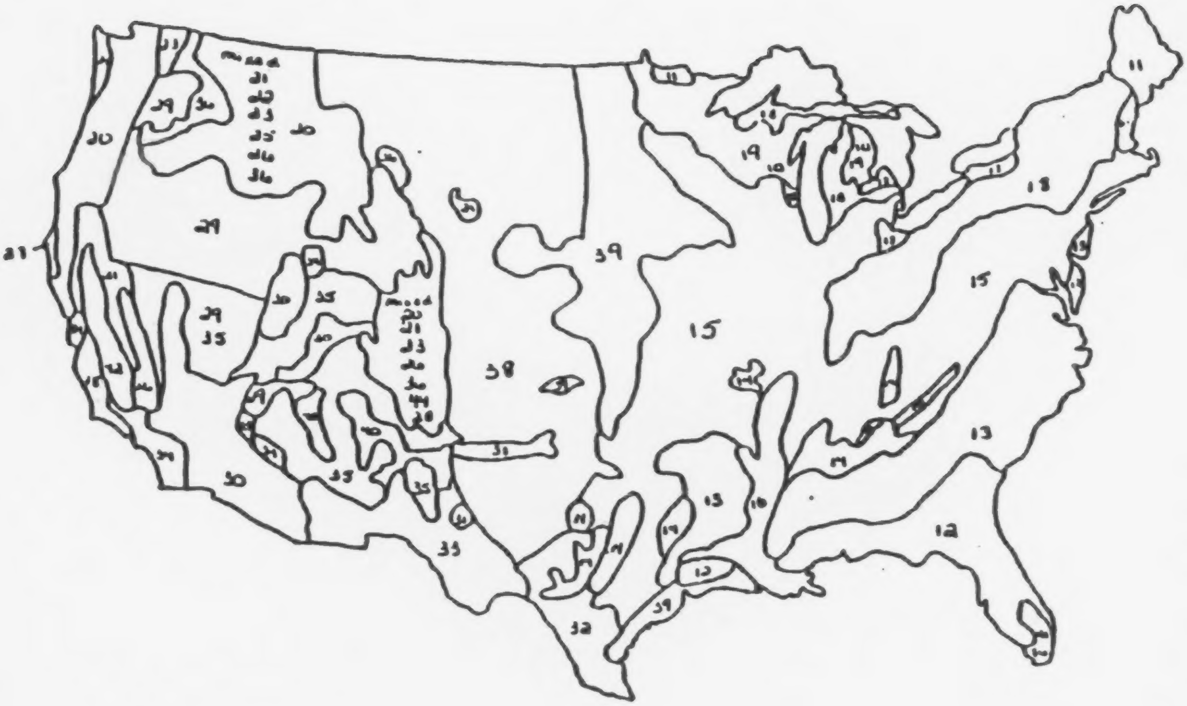
Figure 19. The 31 market regions and livestock producing areas in ARIMS*.


29
Portland
25
Missoula
22
Billings
26
Boise
10
Duluth
16
Pierre
11
Milwaukee
7
Detroit
1
Boston
2
New York
30
San Francisco
Elko
27
23
Denver
North Platte
17
15
St. Joseph
12
Davenport
Columbus
6
3
Norfolk
8
Louisville
13
Cape Girardeau
18
Oklahoma City
31
Los Angeles
24
Albuquerque
28
Phoenix
21
Clovis
4
Charleston
9
Montgomery
14
New Orleans
19
Houston
20
San Antonio
5
Miami

---

* SOURCE: CEPPES.

Figure 20. The 34 ecosystems used in ARIMS*.


30
29
11
18
19
15
13
12
39
38
35
33
32

---

* SOURCE: CEPPES.

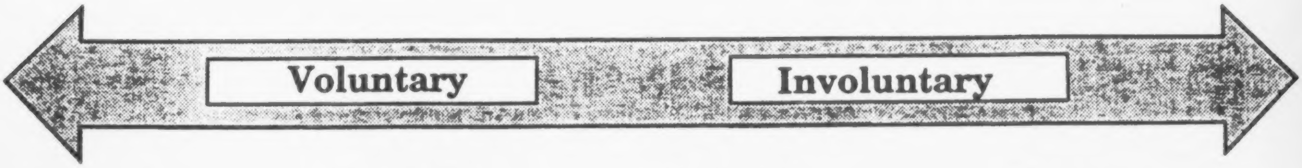
Figure 21. Summary of advantages and disadvantages of remedial methods for aquifer rehabilitation and withdrawal treatment and use*.

			Advantages	Disadvantages
Aquifer Rehabilitation	Withdrawal Treatment and Reinjection		• Perhaps the most widely practiced method for controlling contaminated groundwater	• Expensive • Requires ongoing maintenance and operational costs • No guarantee that entire plume will be intercepted
	In Situ Treatment	Chemical	• Capable of eliminating, immobilizing or precipitating certain chemical species from groundwater	• No guarantee that complete mixing of treating agents occurs • It is hard to estimate just how much of the chemical reagent or biological agent is needed • May be expensive • May cause an adverse impact on the aquifer
		Biological	• Successfully removes petroleum products as well as other organics from groundwater	
Withdrawal Treatment and Use			• Perhaps the most cost effective method	• There may be problems associated with treatment methods of aeration and adsorption

---

* SOURCE: Wright State University, in USDA/SCS, 1987b.

Figure 22. Mandatory versus voluntary programs[*].



Educational

- Public Presentations
- School Programs
- Household Chemical Cleanup Days
- Waste Oil Collection Programs
- Free Water Analysis Programs
- Aquifer Hotlines
- Publicity Tactics
  - -Bumper Stickers
  - -Mascots
  - -Poster Contests
  - -Billboards
  - -Aquifer Area Roadsigns

Operational

- Contamination Hotlines
- Agricultural Practices
  - -Soil Conservation
  - -Limit Chemical Application
- Engineering Practices
- Industrial Practices
- Contingency Programs
  - -Hazardous Material Spill Teams
  - -Water System Interconnection
- Construction Practices

Economic

- Water Use Taxes
- Phased Capital Improvements
- Purchase of Development Rights
- Land Purchase
  - -Watersheds
  - - Sensitive Areas
- Public Land Retention
- Eminent Domain
- Conservation / Scenic Easements
- Restrictive Covenants
- Property Tax Incentives
- Tax Abatements
  - -Water Conservation
  - -Water Saving Device Installation
- Letters of Record to Landowners

Regulatory

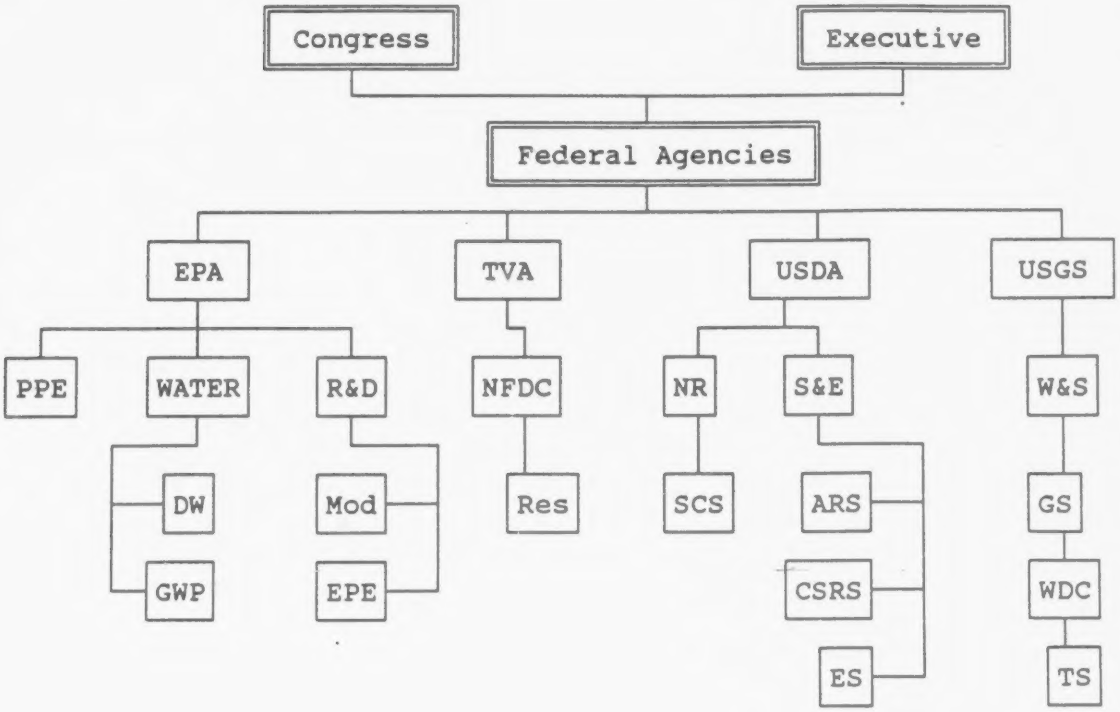
- Special Management Districts
- Zoning Regulations
  - -Special Zoning & Overlay Districts
    - •Floodplain
    - •Conservation
    - •Well Field
  - -Permits and Waivers
  - -Transfer of Development Rights
  - -Performance Standards
  - -Cluster Zoning
  - -Reduced Density Zoning
- Subdivision and Planned Unit Development Ordinances
  - -Building and Landscape Codes
    - •Double Plumbing
    - •Grading & Soil Restoration
    - •Water & Sewer Hookup
- Well Development Standards
  - -Aquifer Penetration Restrictions
- States and Federal Designations (Critical Areas or Sole Source)
- Watershed Rules & Regulations

---

[*] SOURCE: USDA/SCS, 1987b.

4-235

Figure 23. Simplified organizational model of Federal agencies with groundwater programs


Congress
Executive
Federal Agencies
EPA
TVA
USDA
USGS
PPE
WATER
R&D
NFDC
NR
S&E
W&S
DW
Mod
Res
SCS
ARS
GS
GWP
EPE
CSRS
WDC
ES
TS

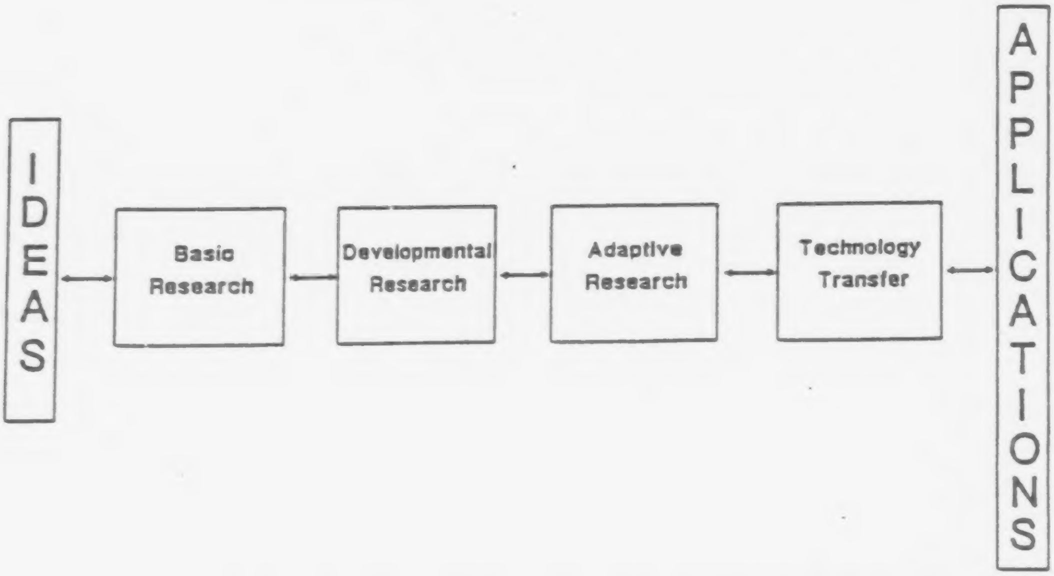
EPA
PPE - Policy, Planning & Evaluation
WATER
DW - Drinking Water
GWP - Groundwater Protection
R&D - Research & Development
Mod - Modeling
EPE - Environmental Processes & Effects

USDA
NR - Natural Resources
SCS - Soil Conservation Service
S&E - Science & Education
ARS - Agricultural Res. Service
CSRS - Coop. State Res. Service
ES - Extension Service

TVA
NFDC - Nat. Fertilizer Development Center
Res - Research

USGS
W&S - Water & Science
GS - Geological Survey
WDC - Water Data Coord.
TS - Toxic Substances*

Figure 24. Defining the process: problem definition, research, extension and technology transfer*.


IDEAS
Basic Research
Developmental Research
Adaptive Research
Technology Transfer
APPLICATIONS

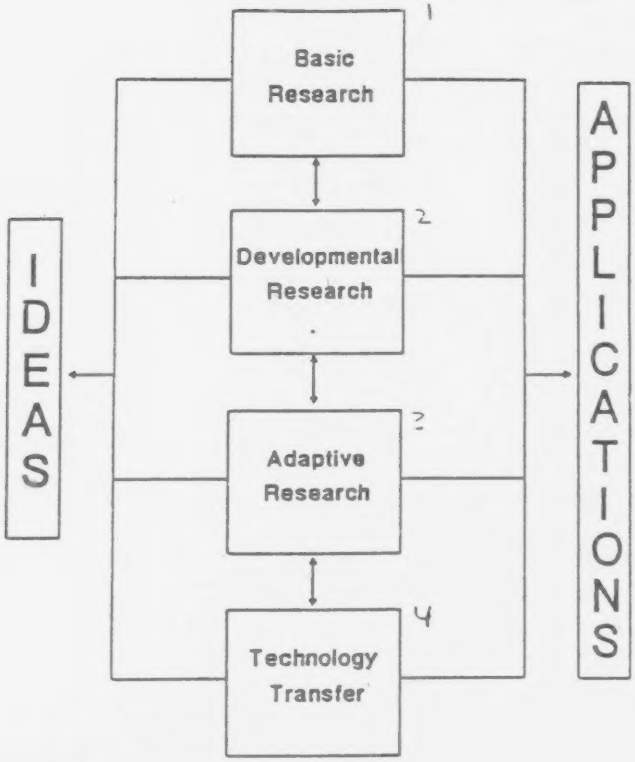
Conceptual model of the U.S. agricultural research and development system, depicting a linear, stepwise process of translating ideas into agricultural applications.

---

[*] SOURCE: Holt, 1989b.

A-237

Figure 25. Facilitating the process: parallel processing of research, extension and technology transfer*.

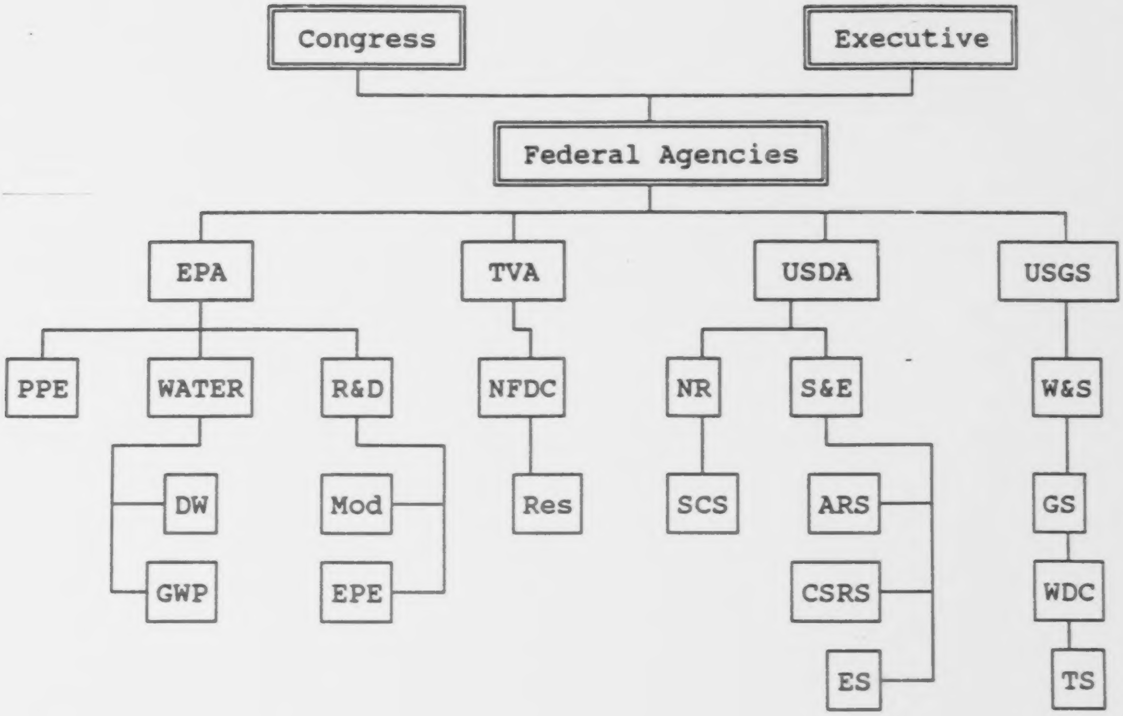

Basic Research
1
Developmental Research
2
Adaptive Research
3
Technology Transfer
4
IDEAS
APPLICATIONS

A parallel model of agricultural research and development, as it might be organized to speed the development of new agricultural technology.

---

* SOURCE: Holt, 1989b.

Figure 26. Applying "parallel processing" to Federal agencies with groundwater programs.


Congress
Executive
Federal Agencies
EPA
TVA
USDA
USGS
PPE
WATER
R&D
NFDC
NR
S&E
W&S
DW
GWP
Mod
EPE
Res
SCS
ARS
CSRS
ES
GS
WDC
TS

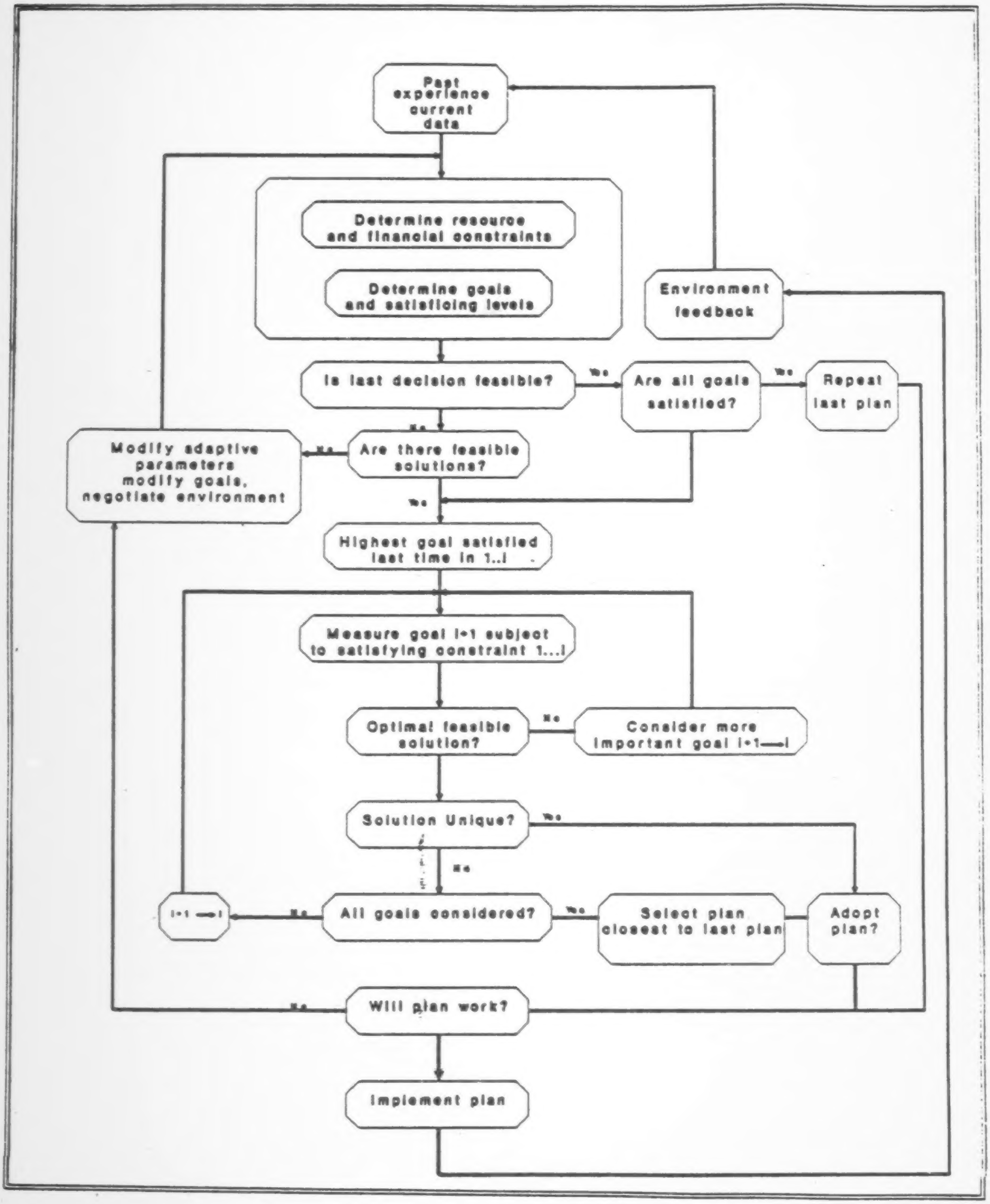
EPA
PPE - Policy, Planning & Evaluation
WATER
DW - Drinking Water
GWP - Groundwater Protection
R&D - Research & Development
Mod - Modeling
EPE - Environmental Processes & Effects

USDA
NR - Natural Resources
SCS - Soil Conservation Service
S&E - Science & Education
ARS - Agricultural Res. Service
CSRS - Coop. State Res. Service
ES - Extension Service

TVA
NFDC - Nat. Fertilizer Development Center
Res - Research

USGS
W&S - Water & Science
GS - Geological Survey
WDC - Water Data Coord.
TS - Toxic Substances*

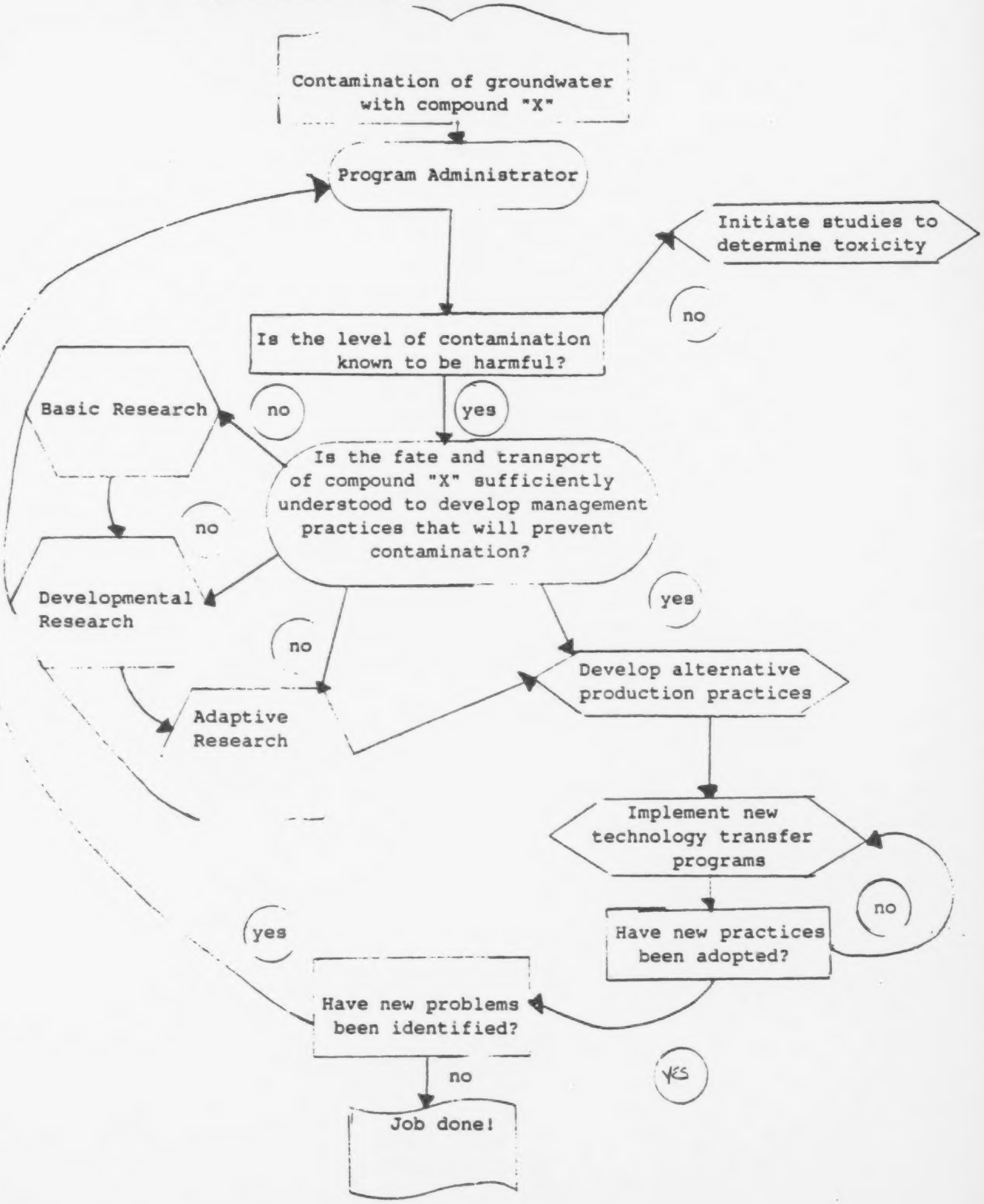
Figure 27. Recursive priority planning*.


Past experience current data
Determine resource and financial constraints
Determine goals and satisficing levels
Environment feedback
Is last decision feasible?
Yes
Are all goals satisfied?
Yes
Repeat last plan
No
Modify adaptive parameters modify goals, negotiate environment
No
Are there feasible solutions?
Yes
Highest goal satisfied last time in 1..I
Measure goal I+1 subject to satisfying constraint 1...I
Optimal feasible solution?
No
Consider more important goal I+1—I
Solution Unique?
Yes
No
I+1 —I
No
All goals considered?
Yes
Select plan closest to last plan
Adopt plan?
No
Will plan work?
Implement plan

---

* SOURCE: CEPPES.

Figure 28. Uncertainty and organizational structure: Well defined problems with well defined organizational responsibilities


Contamination of groundwater with compound "X"
Program Administrator
Initiate studies to determine toxicity
no
Is the level of contamination known to be harmful?
Basic Research
no
yes
Is the fate and transport of compound "X" sufficiently understood to develop management practices that will prevent contamination?
no
Developmental Research
yes
no
Develop alternative production practices
Adaptive Research
Implement new technology transfer programs
no
Have new practices been adopted?
yes
Have new problems been identified?
no
yes
Job done!

A-241

Figure 29. Uncertainty and organizational structure: Poorly defined problems with poorly defined organizational responsibilities

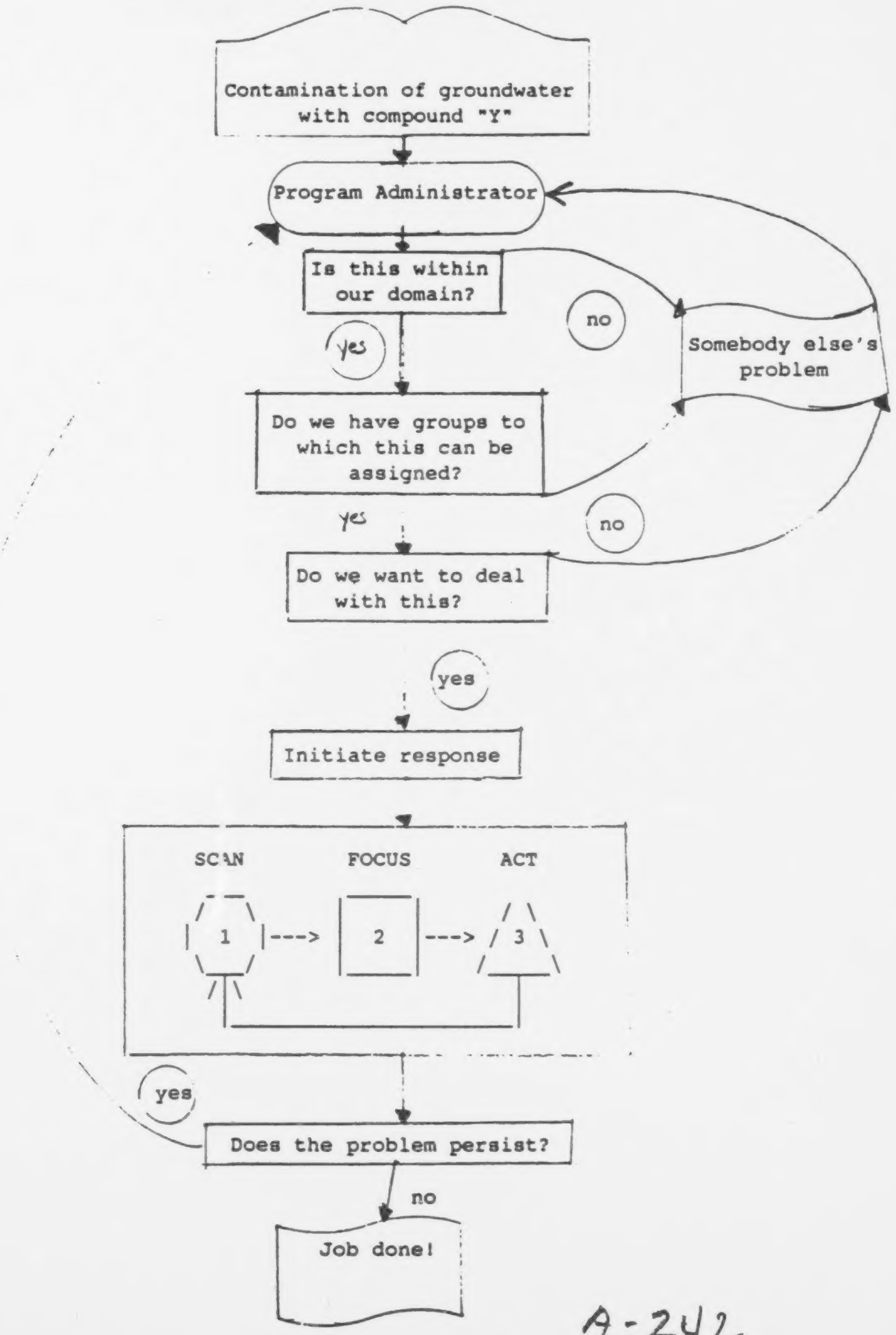
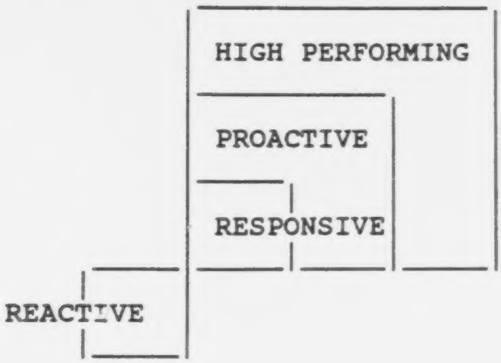
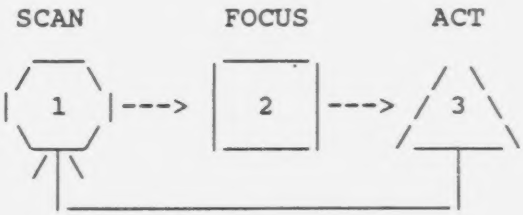

Contamination of groundwater with compound "Y"
Program Administrator
Is this within our domain?
yes
no
Somebody else's problem
Do we have groups to which this can be assigned?
yes
no
Do we want to deal with this?
yes
Initiate response
SCAN
FOCUS
ACT
1
2
3
yes
Does the problem persist?
no
Job done!

Figure 30. Creating an "Excellence Network"*.

1. Modes of organizational reaction


HIGH PERFORMING
PROACTIVE
RESPONSIVE
REACTIVE

2. Organizing for "high performance" programs.


SCAN
FOCUS
ACT
1
2
3

(1) SCAN -- start with an open exchange of information about current realities *and* future opportunities;

(2) FOCUS -- follow with discussions and decisions on overall purpose, outcomes, objectives;

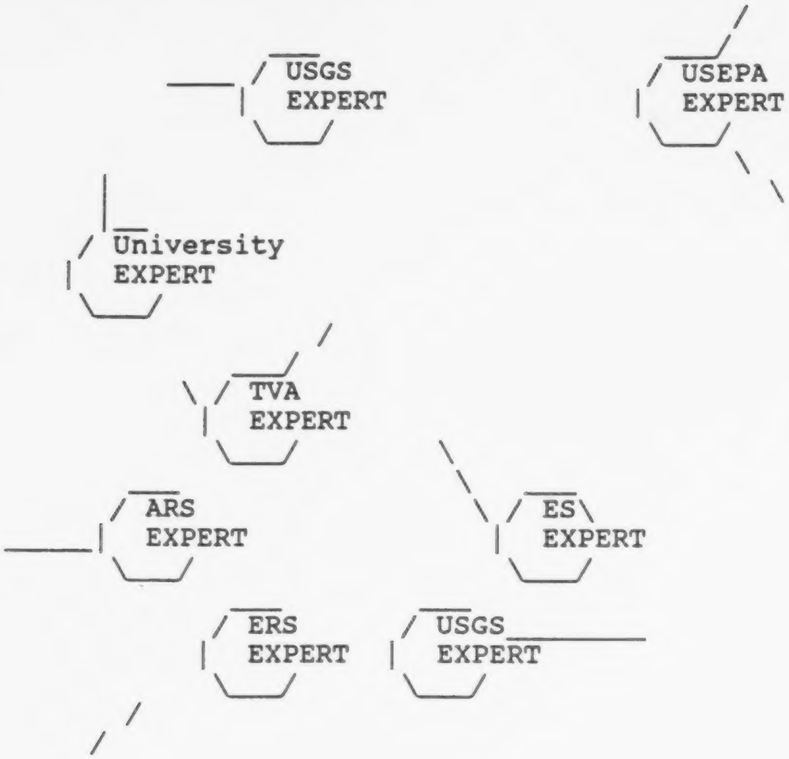
(3) ACT --- conclude with clarification on who's going to do what, when.

---

* SOURCE: Adapted from Carlson, Lemon and Burns, 1987.

Figure 30. Creating an "Excellence Network"

3. Before integration


USGS EXPERT
USEPA EXPERT
University EXPERT
TVA EXPERT
ARS EXPERT
ES EXPERT
ERS EXPERT
USGS EXPERT

4. Integration around a common problem to develop a "high performance" program.

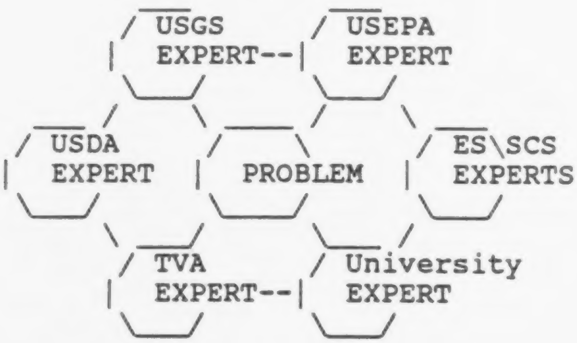

USGS EXPERT
USEPA EXPERT
USDA EXPERT
PROBLEM
ES\SCS EXPERTS
TVA EXPERT
University EXPERT

Figure 30. Creating an "Excellence Network"

5. Expanding to bring in additional expertise and appropriate organizations

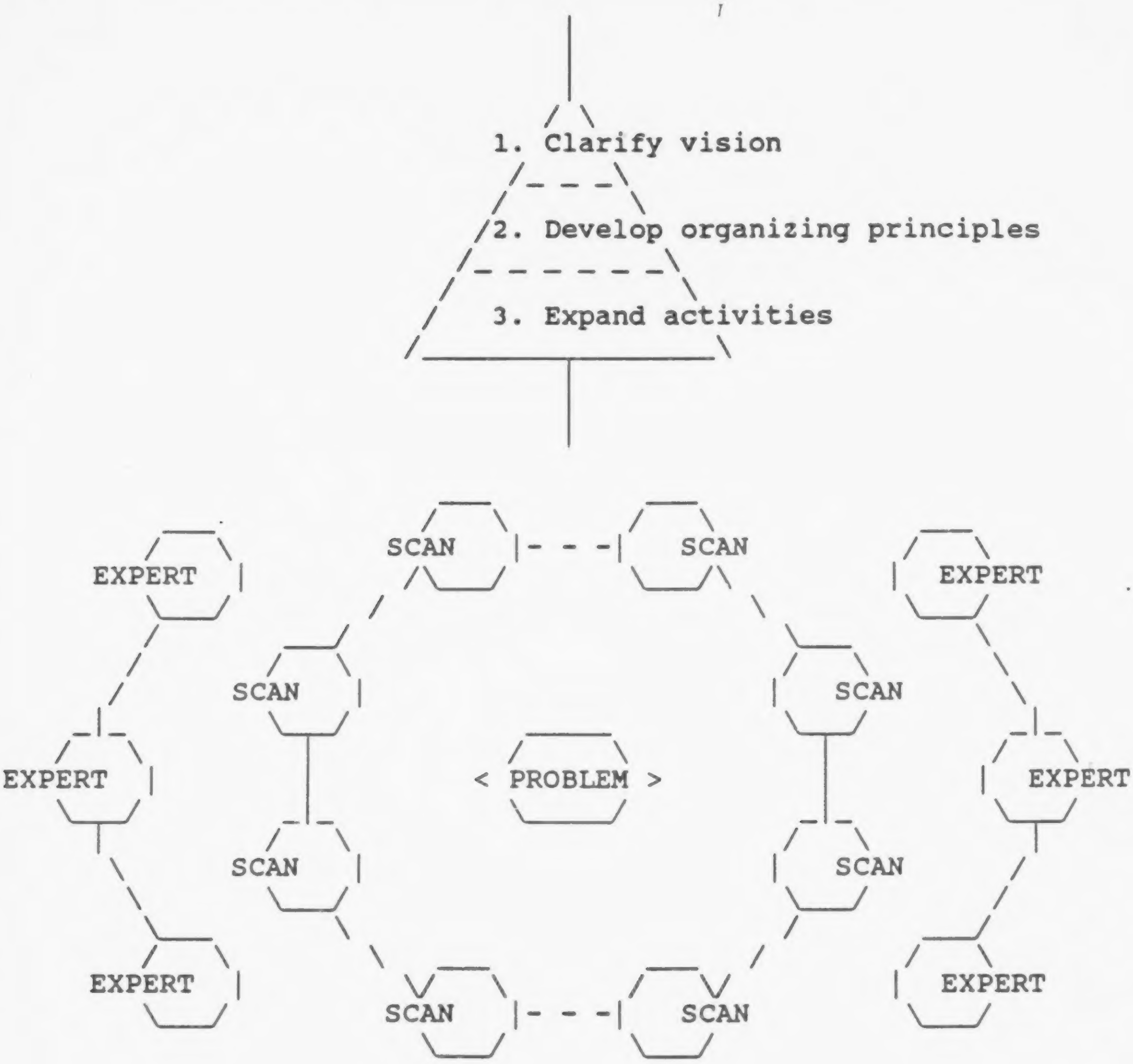

1. Clarify vision
2. Develop organizing principles
3. Expand activities
SCAN
SCAN
EXPERT
EXPERT
SCAN
SCAN
EXPERT
< PROBLEM >
EXPERT
SCAN
SCAN
EXPERT
SCAN
SCAN
EXPERT

Figure 30. Creating an "Excellence Network"

6. Organize experts into "focused" subgroups to address specific problems, within the context of the groups overall agenda

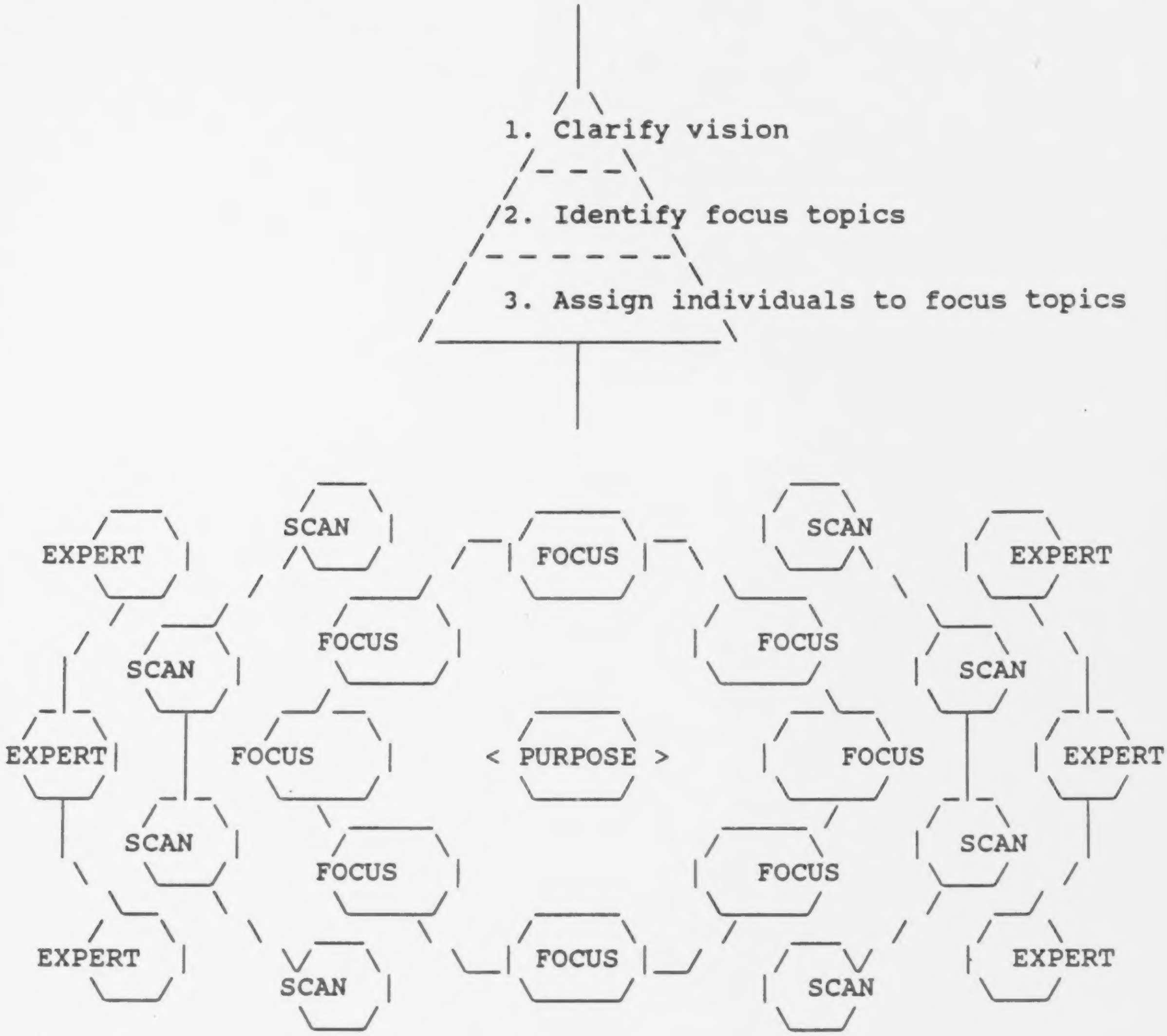
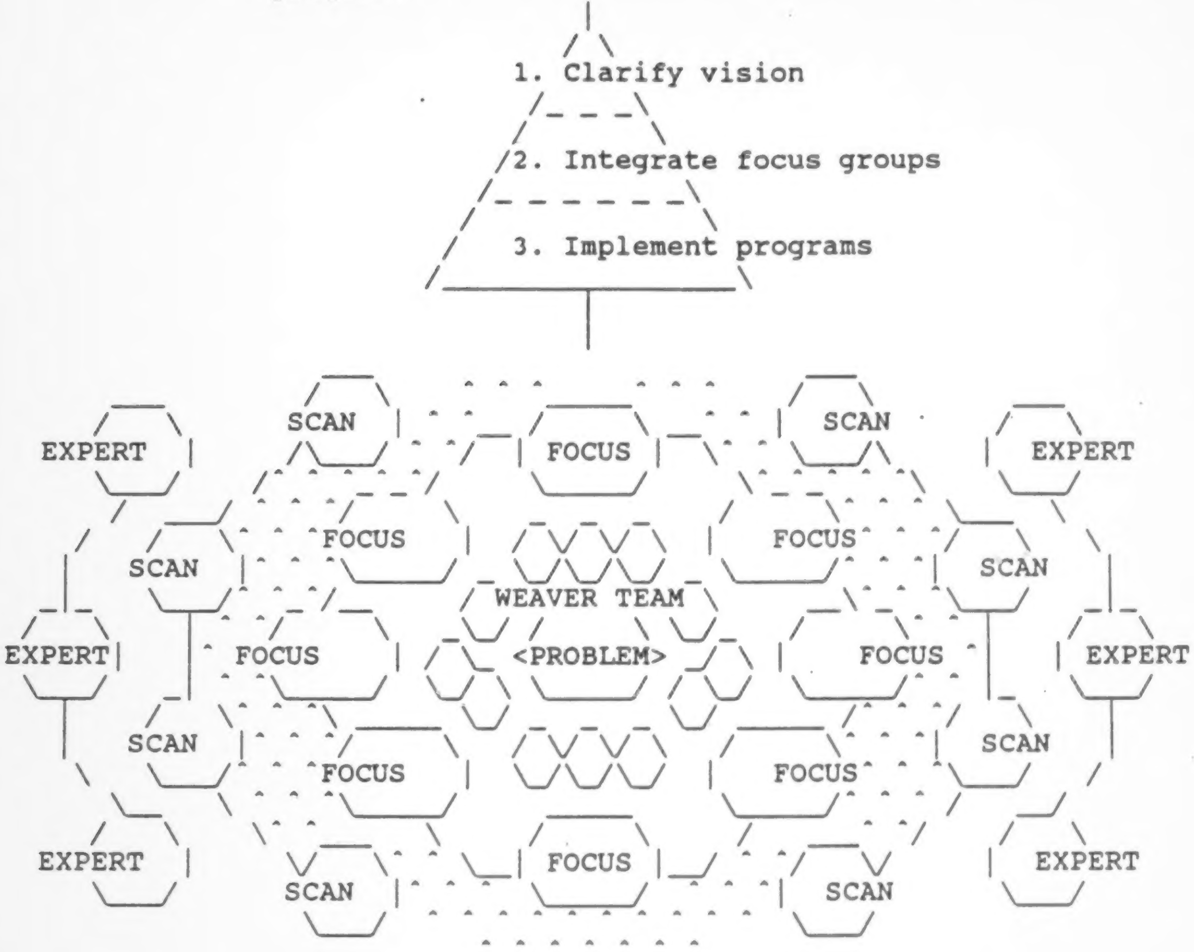

1. Clarify vision
2. Identify focus topics
3. Assign individuals to focus topics
SCAN
EXPERT
FOCUS
SCAN
EXPERT
SCAN
FOCUS
FOCUS
SCAN
EXPERT
FOCUS
< PURPOSE >
FOCUS
EXPERT
SCAN
FOCUS
FOCUS
SCAN
EXPERT
FOCUS
EXPERT
SCAN
SCAN

Figure 30. Creating an "Excellence Network"

7. Integrate efforts of "focus teams" into a comprehensive and coordinated "high performance" program.


1. Clarify vision
2. Integrate focus groups
3. Implement programs
SCAN
FOCUS
SCAN
EXPERT
EXPERT
FOCUS
FOCUS
SCAN
SCAN
WEAVER TEAM
EXPERT
FOCUS
<PROBLEM>
FOCUS
EXPERT
SCAN
SCAN
FOCUS
FOCUS
EXPERT
FOCUS
EXPERT
SCAN
SCAN

8. Incorporate new technologies, secure leadership support in "home" agencies, institutionalize within existing organizational structure.

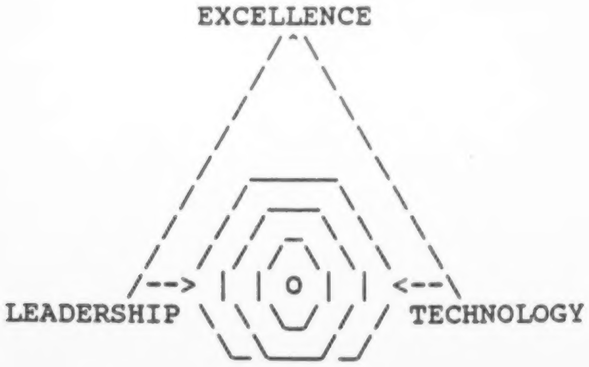

EXCELLENCE
-->
O
<--
LEADERSHIP
TECHNOLOGY

Figure 31. Idealized interagency and intra-agency communication and coordination.

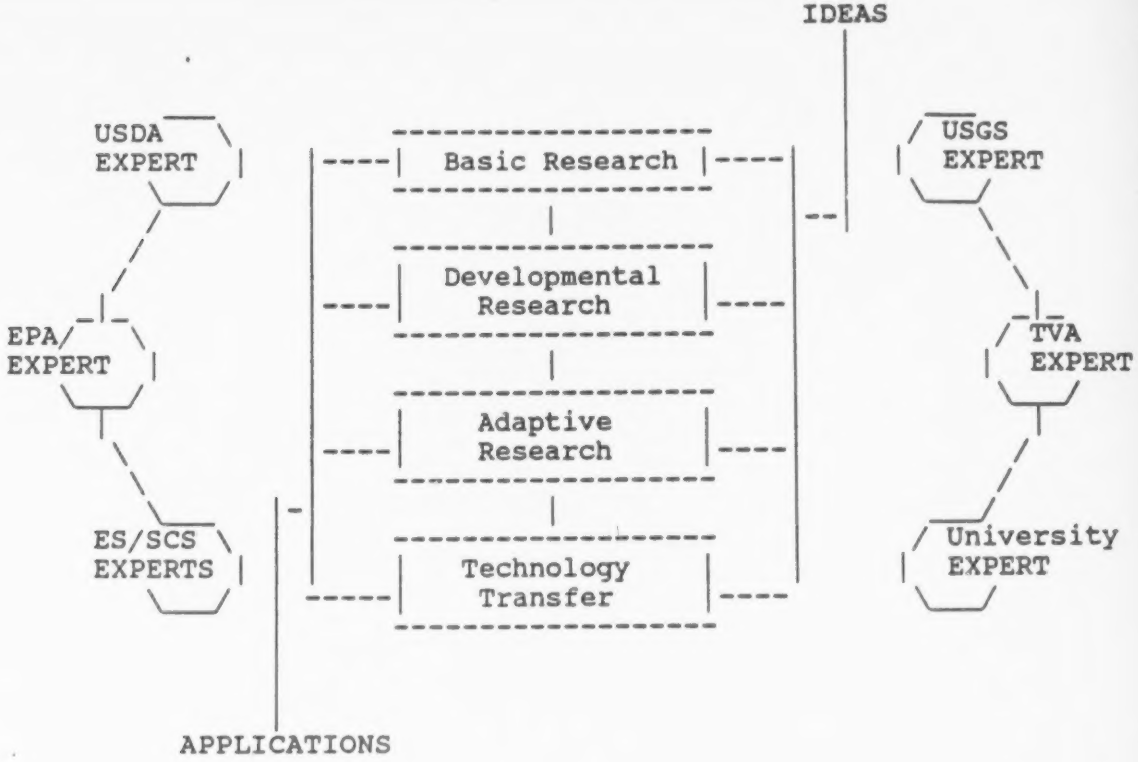

IDEAS
USDA EXPERT
Basic Research
USGS EXPERT
Developmental Research
EPA/ EXPERT
TVA EXPERT
Adaptive Research
ES/SCS EXPERTS
Technology Transfer
University EXPERT
APPLICATIONS

Figure 32. Problem areas in communication and coordination within and among the focus groups.

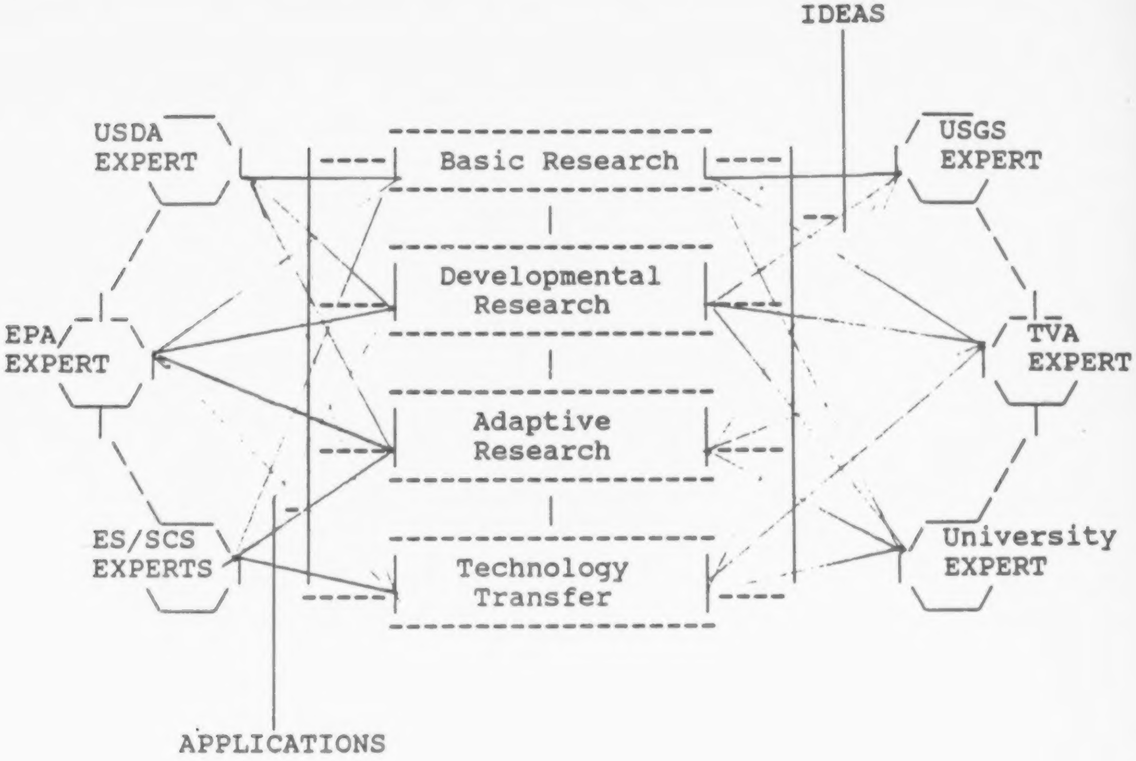
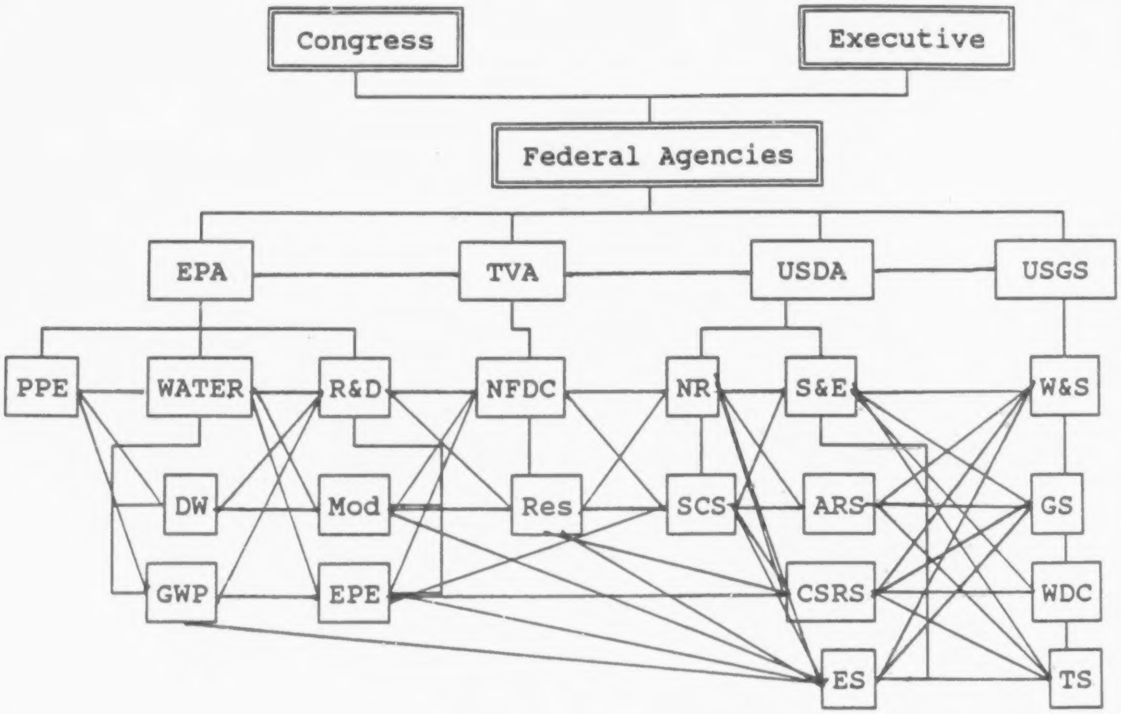

IDEAS
USDA EXPERT
Basic Research
USGS EXPERT
Developmental Research
EPA/ EXPERT
TVA EXPERT
Adaptive Research
ES/SCS EXPERTS
Technology Transfer
University EXPERT
APPLICATIONS

Figure 33. Problem areas in interagency and intra-agency communication and coordination.


Congress
Executive
Federal Agencies
EPA
TVA
USDA
USGS
PPE
WATER
R&D
NFDC
NR
S&E
W&S
DW
Mod
Res
SCS
ARS
GS
GWP
EPE
CSRS
WDC
ES
TS

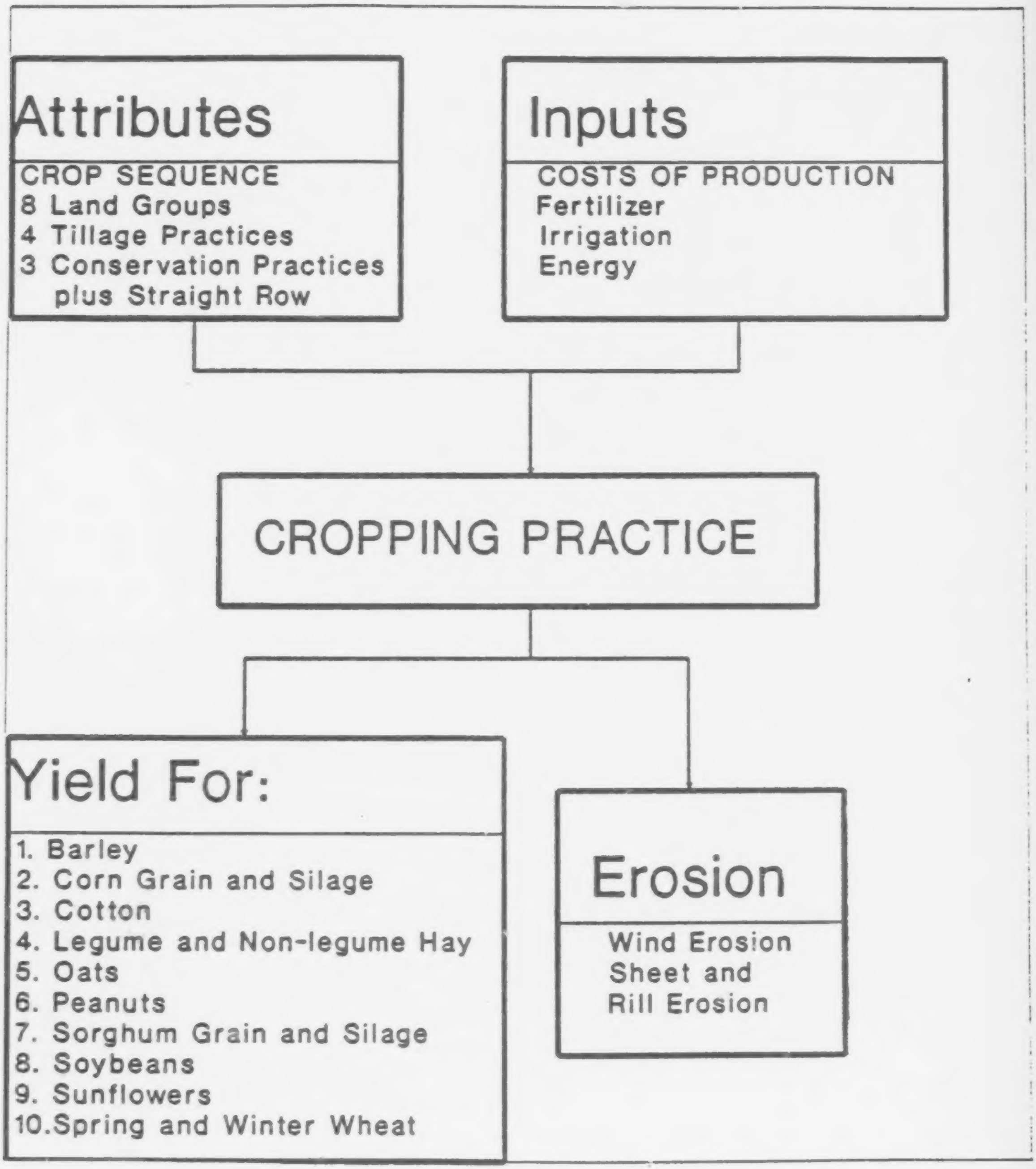
EPA
PPE - Policy, Planning & Evaluation
WATER
DW - Drinking Water
GWP - Groundwater Protection
R&D - Research & Development
Mod - Modeling
EPE - Environmental Processes & Effects

USDA
NR - Natural Resources
SCS - Soil Conservation Service
S&E - Science & Education
ARS - Agricultural Res. Service
CSRS - Coop. State Res. Service
ES - Extension Service

TVA
NFDC - Nat. Fertilizer Development Center
Res - Research

USGS
W&S - Water & Science
GS - Geological Survey
WDC - Water Data Coord.
TS - Toxic Substances*

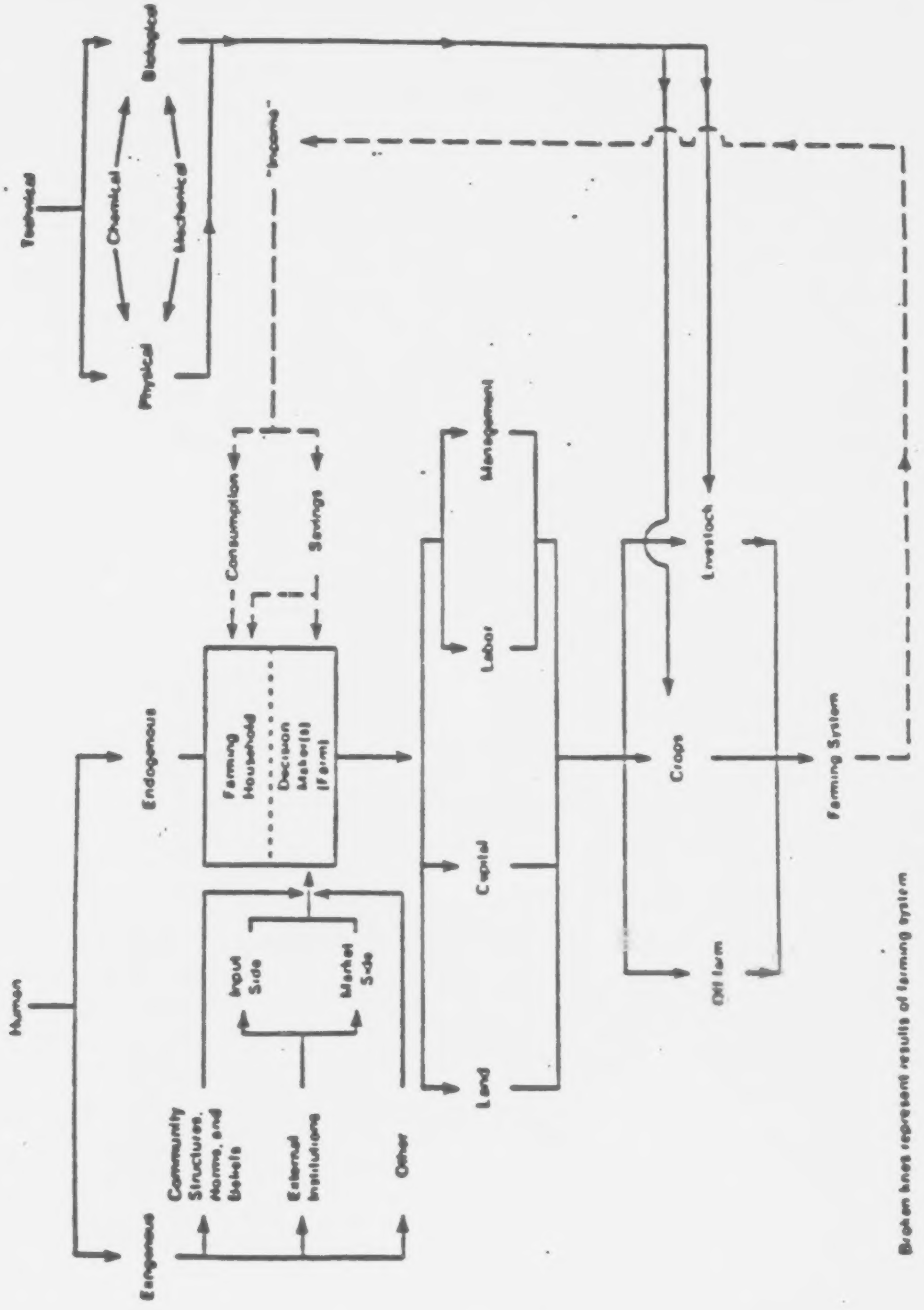
Figure 34. Attributes of the crop sector*.


Attributes
CROP SEQUENCE
8 Land Groups
4 Tillage Practices
3 Conservation Practices plus Straight Row
Inputs
COSTS OF PRODUCTION
Fertilizer
Irrigation
Energy
CROPPING PRACTICE
Yield For:
1. Barley
2. Corn Grain and Silage
3. Cotton
4. Legume and Non-legume Hay
5. Oats
6. Peanuts
7. Sorghum Grain and Silage
8. Soybeans
9. Sunflowers
10.Spring and Winter Wheat
Erosion
Wind Erosion
Sheet and Rill Erosion

---

* SOURCE: CEPPES.

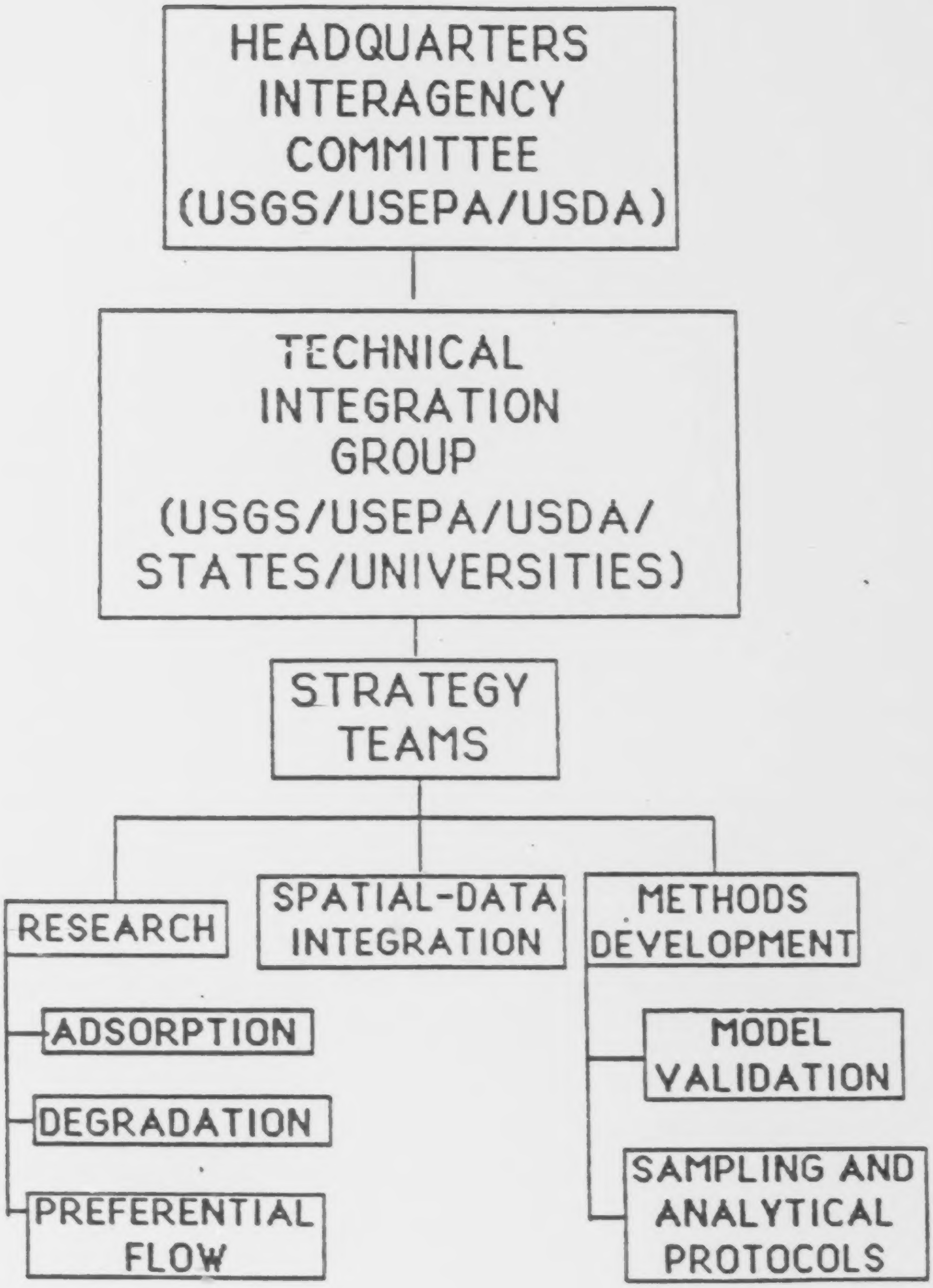
Figure 35. Schematic representation of some determinants of the farm system*.


Technical
Chemical
Mechanical
Biological
Physical
"Income"
Consumption
Savings
Farming Household
Decision Maker(s) (Farm)
Management
Labor
Capital
Land
Livestock
Crops
Off farm
Farming System
Human
Endogenous
Exogenous
Community Structures, Norms, and Beliefs
External Institutions
Other
Input Side
Market Side
Broken lines represent results of farming system

---

[*] SOURCE: CEPPES.

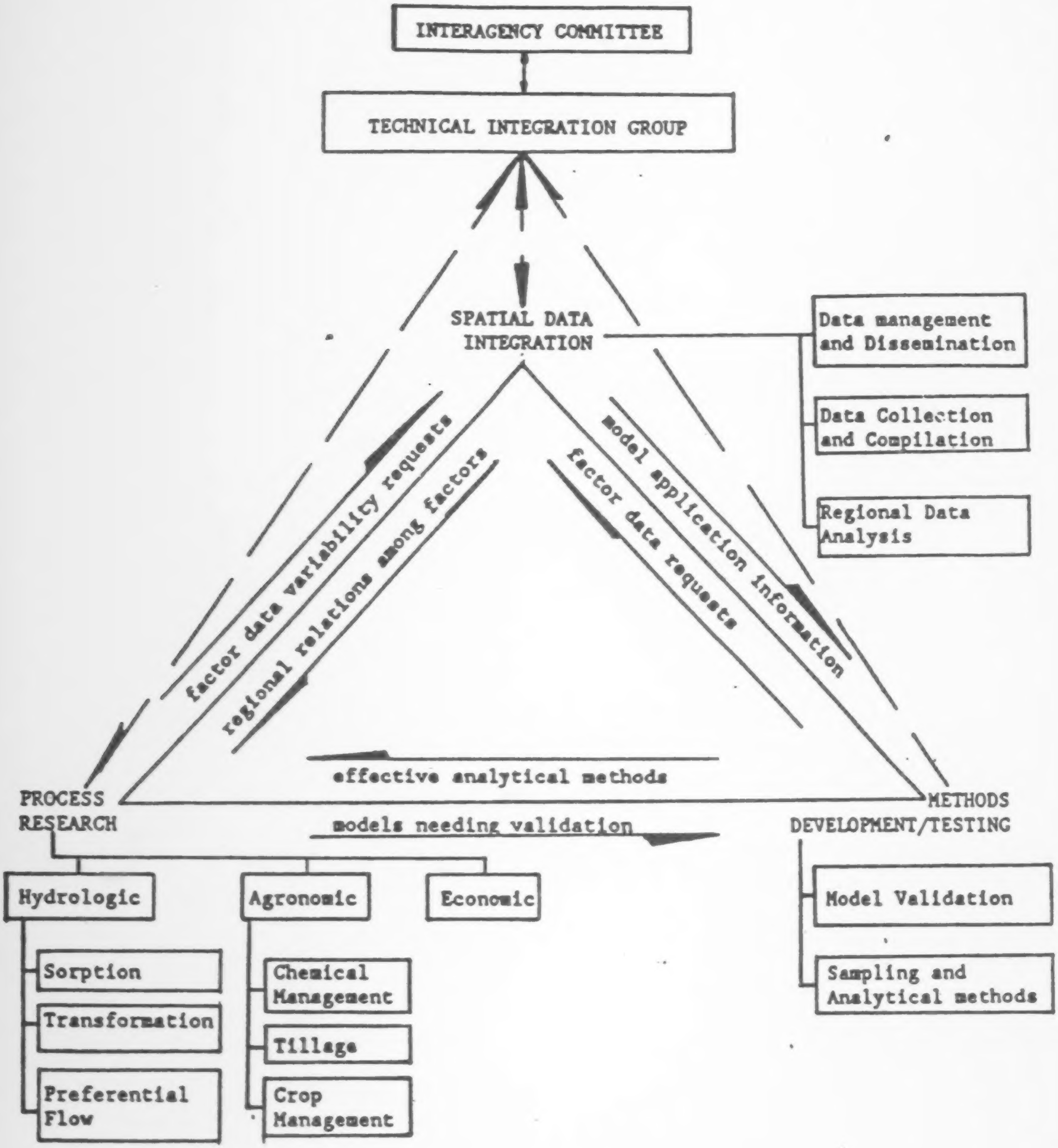
Figure 36. The "technical integration group": Structure*.


HEADQUARTERS INTERAGENCY COMMITTEE (USGS/USEPA/USDA)
TECHNICAL INTEGRATION GROUP (USGS/USEPA/USDA/ STATES/UNIVERSITIES)
STRATEGY TEAMS
RESEARCH
SPATIAL-DATA INTEGRATION
METHODS DEVELOPMENT
ADSORPTION
DEGRADATION
PREFERENTIAL FLOW
MODEL VALIDATION
SAMPLING AND ANALYTICAL PROTOCOLS

---

* SOURCE: Ragone, 1989.

Figure 37. The "technical integration group": Function*.


INTERAGENCY COMMITTEE
TECHNICAL INTEGRATION GROUP
SPATIAL DATA INTEGRATION
Data management and Dissemination
Data Collection and Compilation
Regional Data Analysis
factor data variability requests
regional relations among factors
model application information
factor data requests
effective analytical methods
models needing validation
PROCESS RESEARCH
METHODS DEVELOPMENT/TESTING
Hydrologic
Agronomic
Economic
Sorption
Transformation
Preferential Flow
Chemical Management
Tillage
Crop Management
Model Validation
Sampling and Analytical methods

---

[*] SOURCE: Ragone, 1989.

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Figure 38. A research matrix*.

	Hydrologic System Components				
	Atmosphere	Soil/ Root Zone	Unsaturated Zone	Saturated Zone	Surface Water
MASS BALANCE ELEMENTS Processes					
TRANSPORT					
Volatilization					
Plant uptake					
Diffusion					
Solution					
Capillary Flow					
Macropore Flow					
TRANSFORMATION					
Biological					
Chemical					
Photo					
STORAGE					
Solution					
Sorption (minerals)					
Sorption (organics)					
Bioaccumulation					

· Matrix of physical compartments and processes affecting atrazine.

---

* SOURCE: Ragone, 1989.

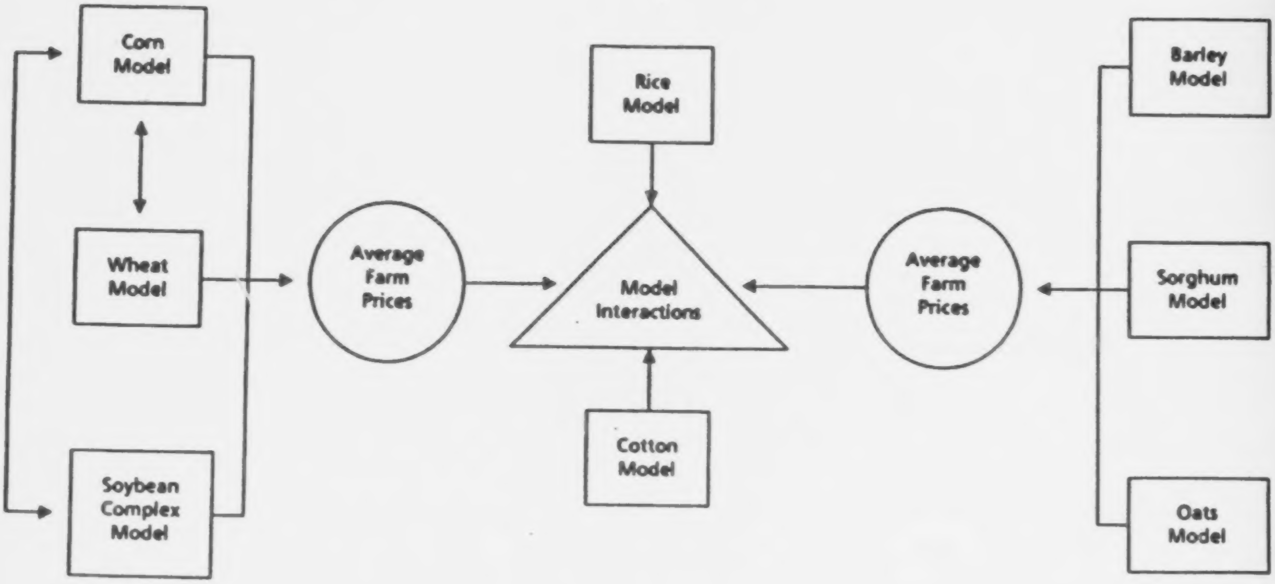
Figure 40. A classification algorithm.

```
(1)  Does the project involve data collection?
     {If YES, proceed, if NO go to 2}
     a.   Does the project involve monitoring?
          {If YES, proceed, if NO go to b}
          1.   How many samples will be taken?
          2.   How often will samples be taken?
          3.   Describe samples.
          4.   Describe sampling techniques.
     {GO TO (6)
     b.   If project does not include monitoring (i.e., data
          collected only once} describe temporal and spatial
          variability that may effect sample values
     c.  Will the data be analyzed, or passed along to someone else?
(2)  Does the project have an experimental design?
     {If YES, proceed, if NO go to 3}
     a.   What is experiment's hypothesis?
     b.   What is the null hypothesis?
     c.   What magnitude of measured difference will have to be
          observed to detect significance?
     {GO TO (6)
(3)  Does the project include interpretive analysis?
     {If YES, proceed, if NO go to 4}
     {GO TO (6)
(4)  Does the project involve policy analysis?
     {If YES, proceed, if NO go to 5}
     {GO TO (6)
(5)  Does the project include technology transfer?
     {If YES, proceed}
     {GO TO (6)

END

(6)  Evaluation module
     a.   What percent of the project's budget will be spent
          on this activity?
     b.   What percent of the projects "full-time equivalents" (or
          "scientist-years" will be spent on this activity?
     c.   Is this activity:
          (1) directly relevant to groundwater protection?
          (2) potentially relevant to groundwater protection?
     RETURN
```

Figure 41. Structure of U.S. domestic crops models*.


Corn Model
Wheat Model
Soybean Complex Model
Average Farm Prices
Rice Model
Model Interactions
Cotton Model
Average Farm Prices
Barley Model
Sorghum Model
Oats Model

---

* SOURCE: CEPPES.

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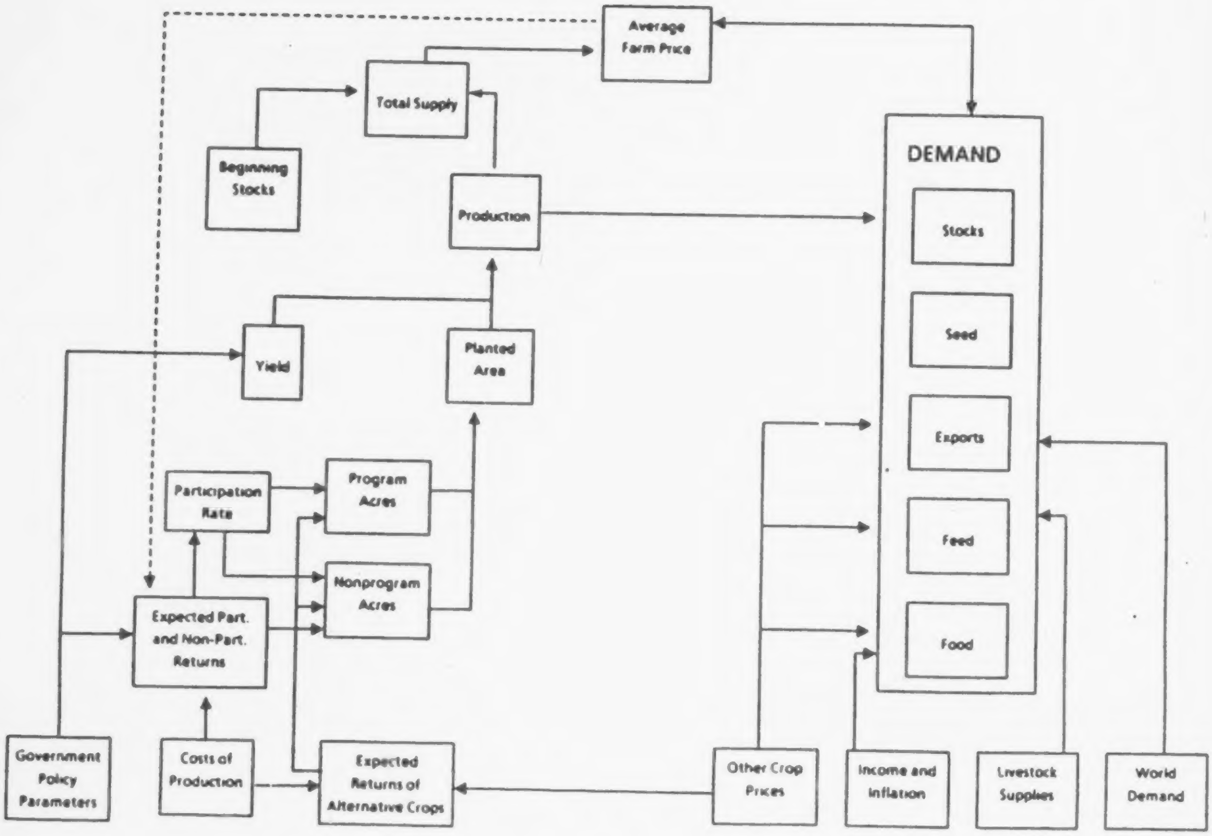
Figure 42. General Structure of a domestic crop model*.


Average Farm Price
Total Supply
Beginning Stocks
Production
DEMAND
Stocks
Seed
Exports
Feed
Food
Yield
Planted Area
Participation Rate
Program Acres
Nonprogram Acres
Expected Part. and Non-Part. Returns
Government Policy Parameters
Costs of Production
Expected Returns of Alternative Crops
Other Crop Prices
Income and Inflation
Livestock Supplies
World Demand

---

* SOURCE: CEPPES.

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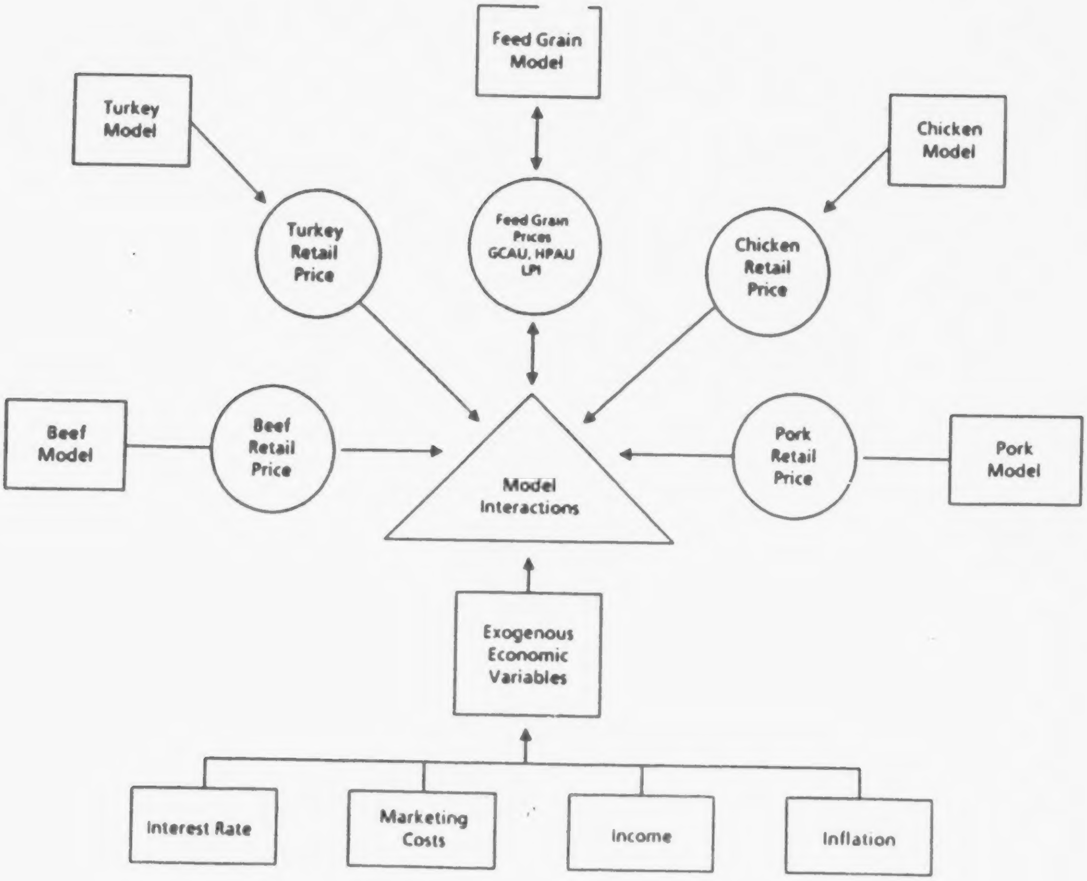
>>> FT <<<

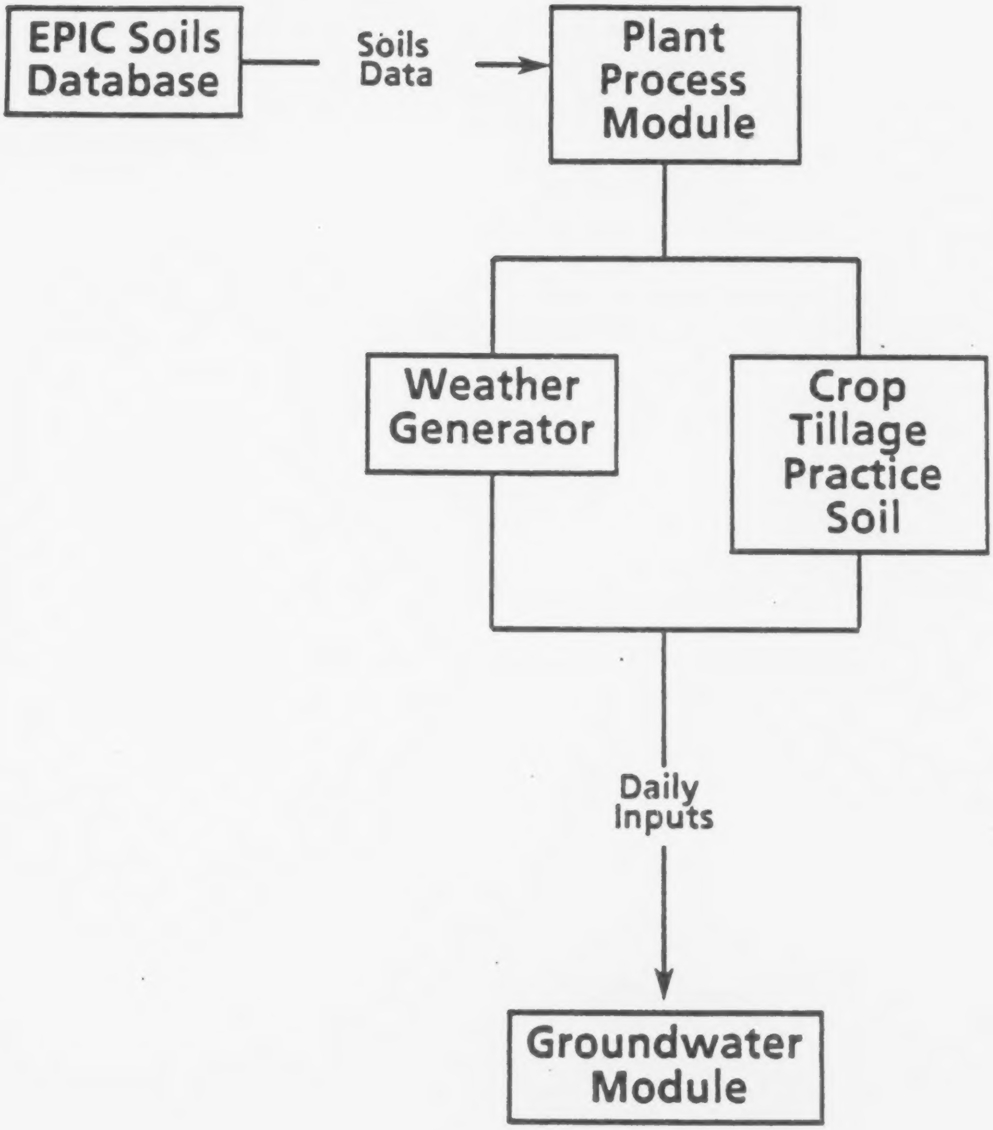
Figure 43. Livestock sector model linkages*.


Feed Grain Model
Turkey Model
Chicken Model
Turkey Retail Price
Feed Grain Prices GCAU, HPAU LPI
Chicken Retail Price
Beef Model
Beef Retail Price
Model Interactions
Pork Retail Price
Pork Model
Exogenous Economic Variables
Interest Rate
Marketing Costs
Income
Inflation

---

* SOURCE: CEPPES.

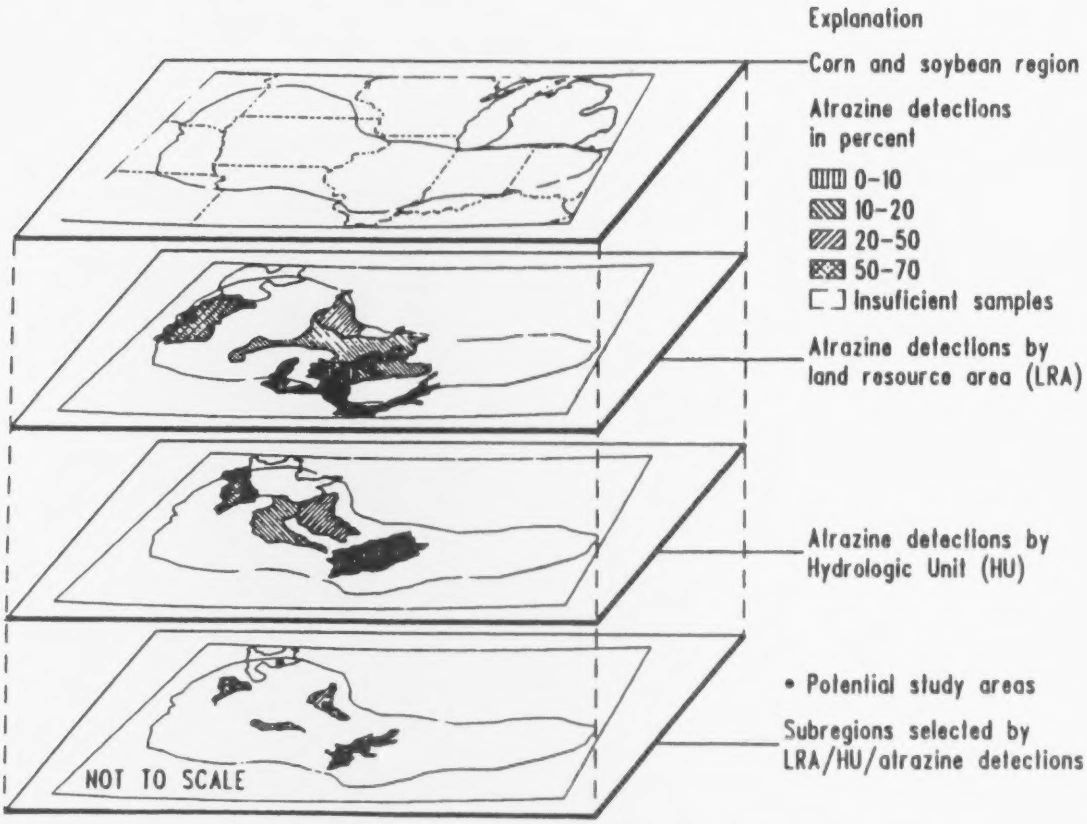
Figure 44. Linkages between plant process and groundwater modules*.


EPIC Soils Database
Soils Data
Plant Process Module
Weather Generator
Crop Tillage Practice Soil
Daily Inputs
Groundwater Module

---

* SOURCE: CEPPES.

Figure 45. Geographic information systems*.


Explanation
Corn and soybean region
Atrazine detections in percent
▥ 0-10
▧ 10-20
▨ 20-50
▩ 50-70
☐ Insuficient samples
Atrazine detections by land resource area (LRA)
Atrazine detections by Hydrologic Unit (HU)
• Potential study areas
Subregions selected by LRA/HU/atrazine detections
NOT TO SCALE

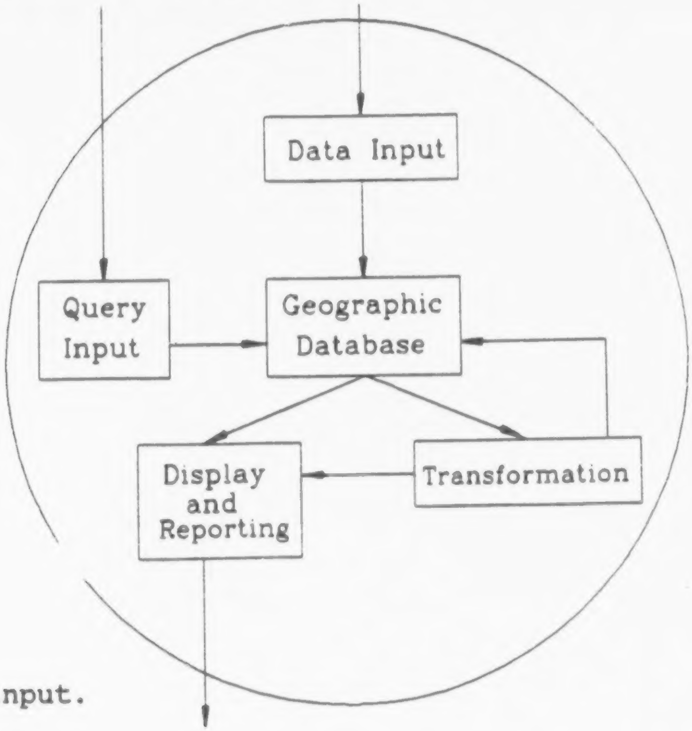
Regional, subregional and area delineations for factor verification or further study by a geographic information system.

---

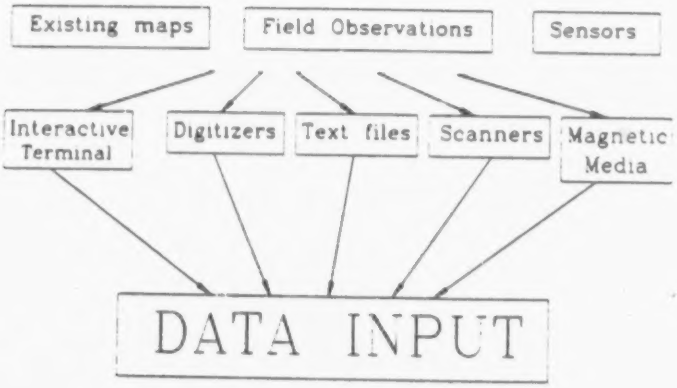
* SOURCE: Ragone et al., 1989.

Figure 46. Components of geographic information systems*.

1. Main software components.


Data Input
Query Input
Geographic Database
Display and Reporting
Transformation

2. Data input.

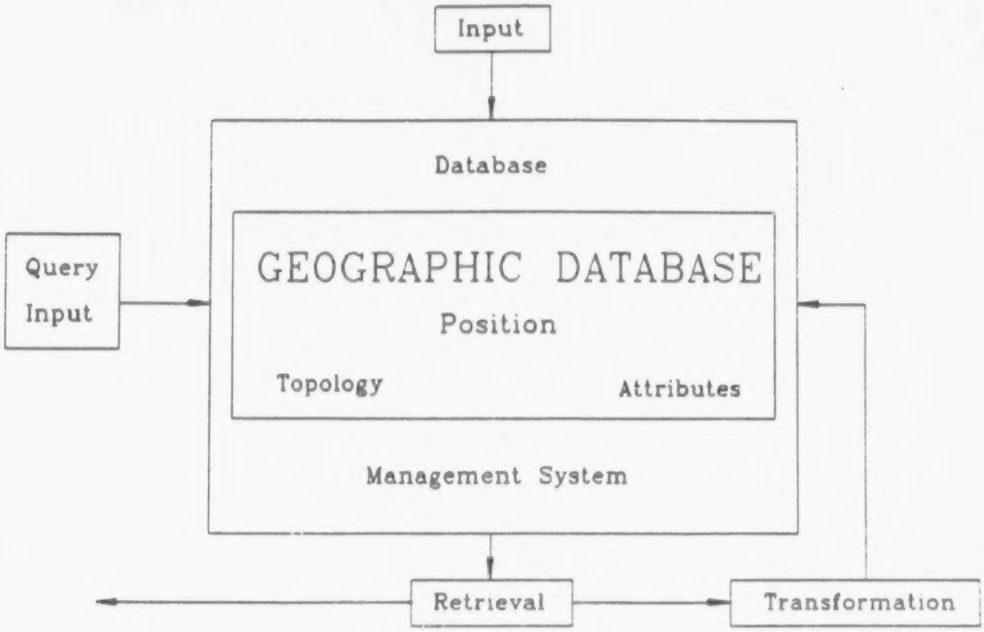

Existing maps
Field Observations
Sensors
Interactive Terminal
Digitizers
Text files
Scanners
Magnetic Media
DATA INPUT

---

* SOURCE: Burrough, 1989.

Figure 46. Components of geographic information systems

3. Components of the geographic database.


Input
Database
Query Input
GEOGRAPHIC DATABASE
Position
Topology
Attributes
Management System
Retrieval
Transformation

4. Data output.

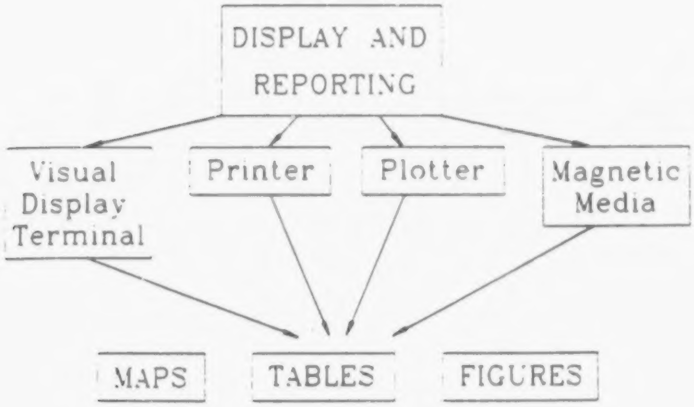
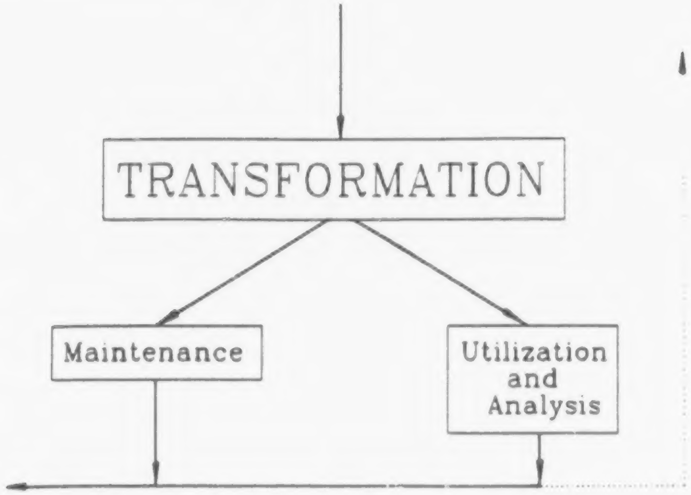

DISPLAY AND REPORTING
Visual Display Terminal
Printer
Plotter
Magnetic Media
MAPS
TABLES
FIGURES

Figure 46. Components of geographic information systems

5. Data transformation.


TRANSFORMATION
Maintenance
Utilization and Analysis

6. Organizational aspects of geographic information systems.

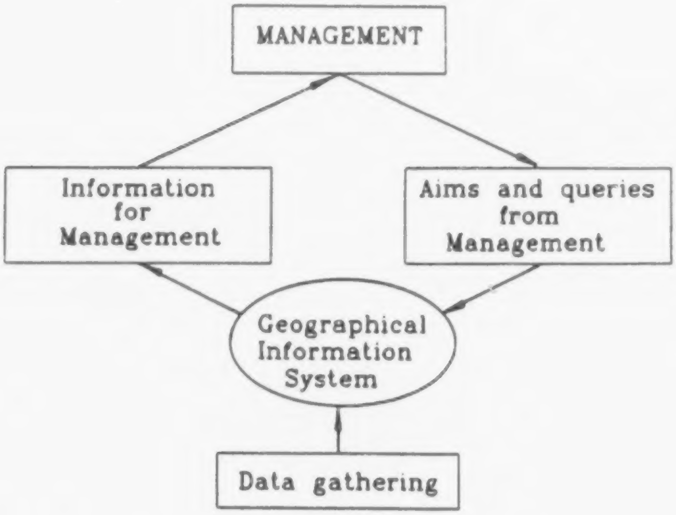
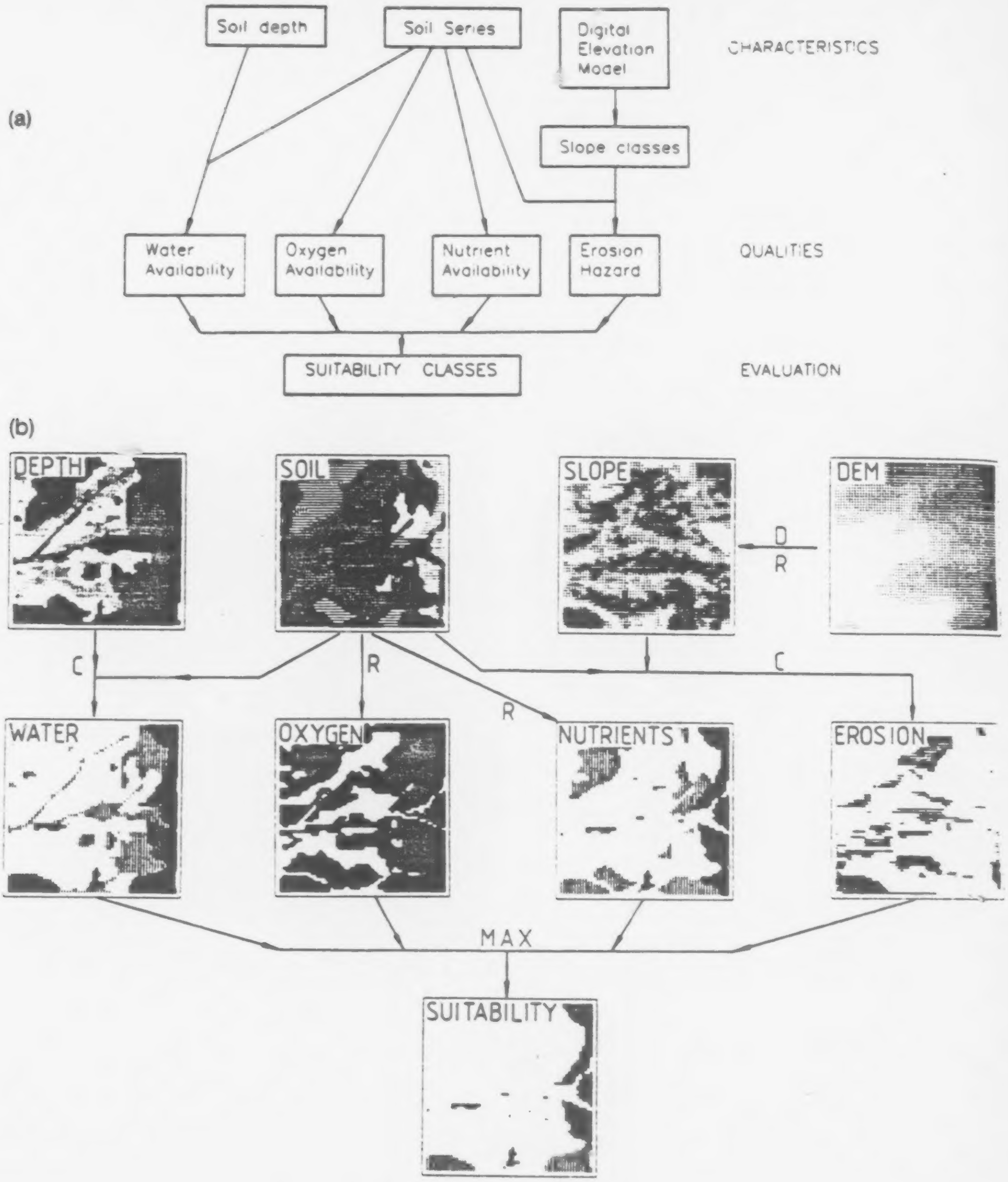

MANAGEMENT
Information for Management
Aims and queries from Management
Geographical Information System
Data gathering

Figure 47. Flowchart of the operations needed to create a map of suitability classes for maize*.


(a)
Soil depth
Soil Series
Digital Elevation Model
CHARACTERISTICS
Slope classes
Water Availability
Oxygen Availability
Nutrient Availability
Erosion Hazard
QUALITIES
SUITABILITY CLASSES
EVALUATION
(b)
DEPTH
SOIL
SLOPE
DEM
D
R
C
R
C
R
WATER
OXYGEN
NUTRIENTS
EROSION
MAX
SUITABILITY

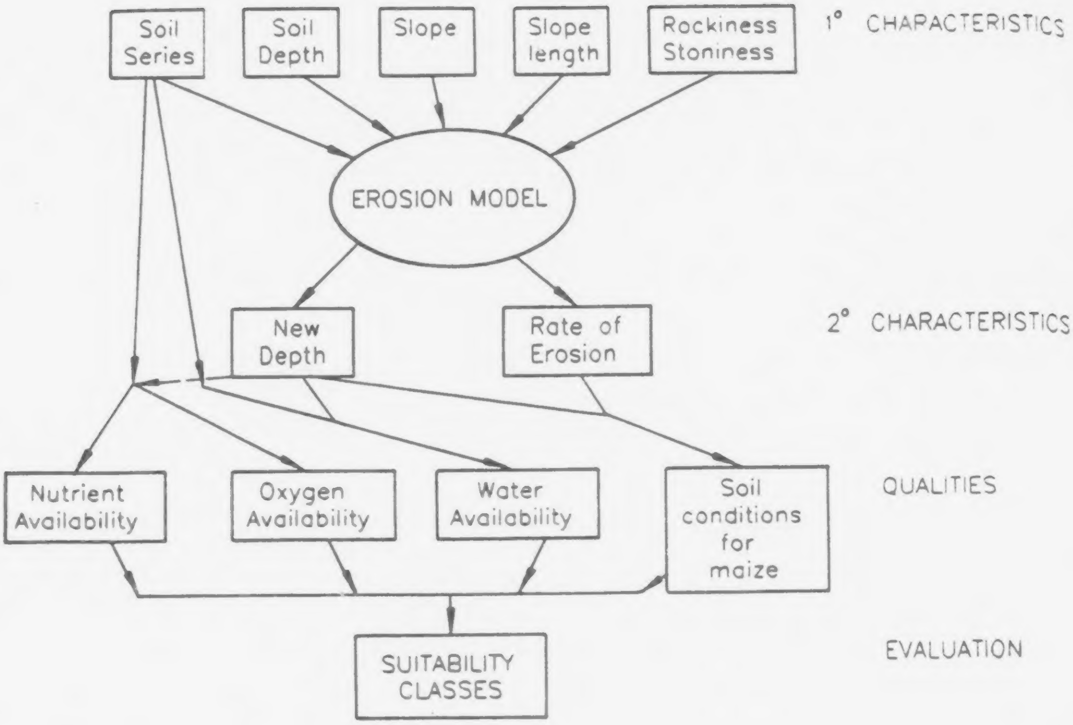
C = CROSS operation; R = RENUMBER operation;
D = DIFFERENTIATE operation; MAX = MAXIMIZE operation. Darker tones on all maps except 'SOIL' indicate 'more' or 'better'.

Key to maps: DEPTH = soil depth classes; SOIL = soil series; SLOPE = slope classes; DEM = digital elevation model; WATER = land quality map of water supply for roots; OXYGEN = idem for oxygen supply; NUTRIENTS = idem for nutrients; EROSION = susceptibility to erosion under maize; SUITABILITY = final result.

---

* SOURCE: Burrough, 1989.

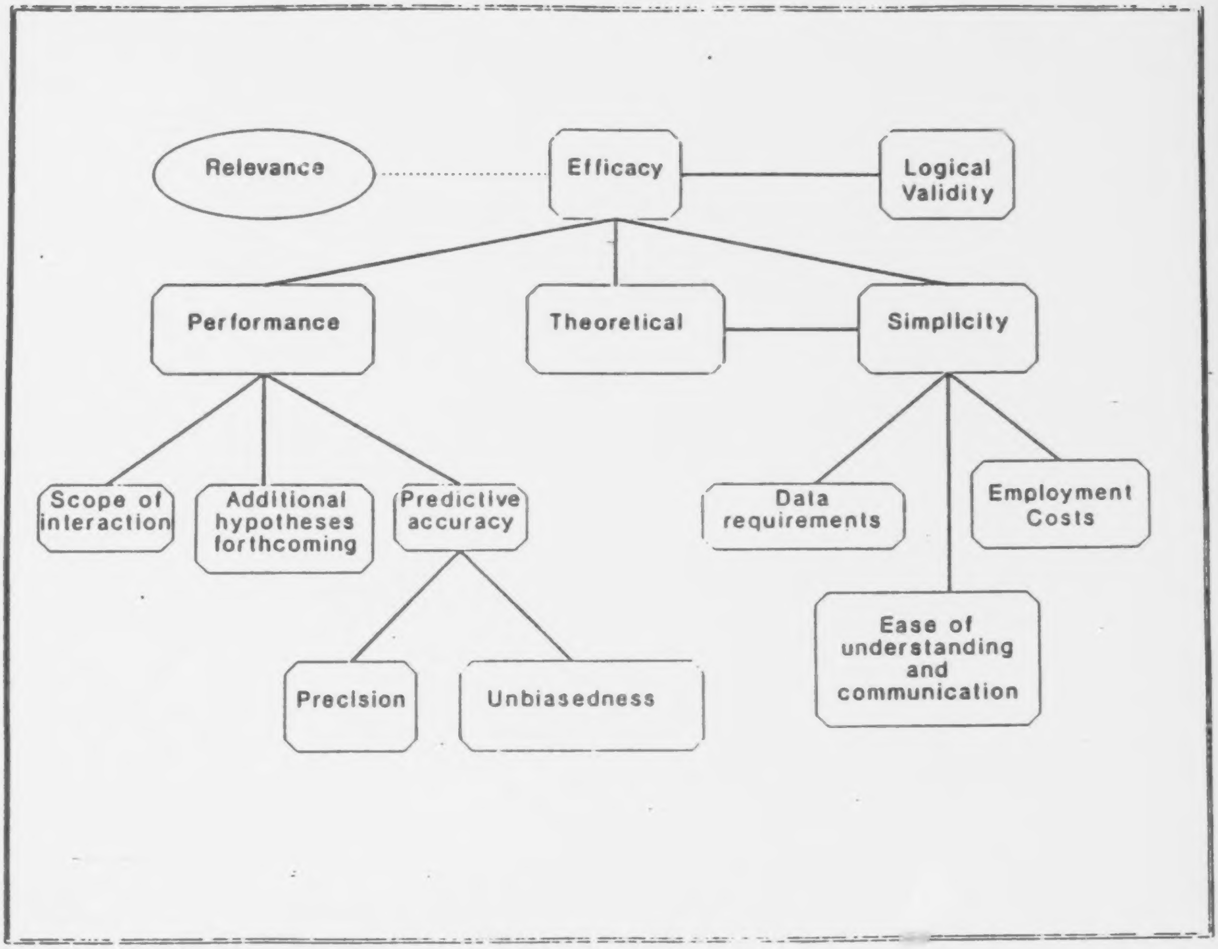
Figure 48. Components of a Management Information System (MIS)*.


Soil Series
Soil Depth
Slope
Slope length
Rockiness Stoniness
1° CHARACTERISTICS
EROSION MODEL
New Depth
Rate of Erosion
2° CHARACTERISTICS
Nutrient Availability
Oxygen Availability
Water Availability
Soil conditions for maize
QUALITIES
SUITABILITY CLASSES
EVALUATION

---

* SOURCE: Burrough, 1989.

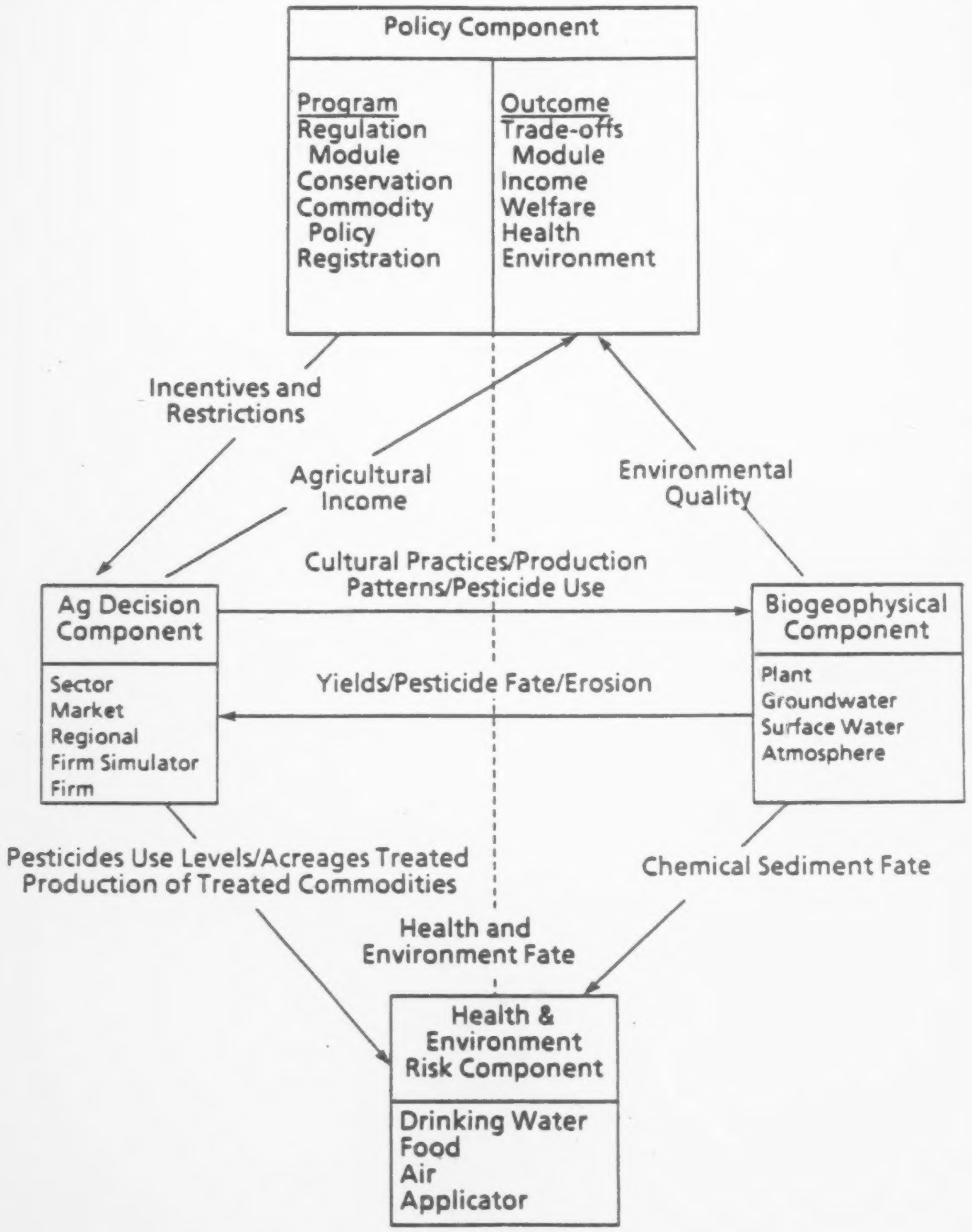
Figure 49. Criteria for evaluating decision-making models[*].


Relevance
Efficacy
Logical Validity
Performance
Theoretical
Simplicity
Scope of interaction
Additional hypotheses forthcoming
Predictive accuracy
Data requirements
Employment Costs
Ease of understanding and communication
Precision
Unbiasedness

---

[*] SOURCE: CEPPES.

Figure 50. Integrated policy evaluation system for agriculture*.


Policy Component
Program
Regulation Module
Conservation
Commodity Policy
Registration
Outcome
Trade-offs Module
Income
Welfare
Health
Environment
Incentives and Restrictions
Agricultural Income
Environmental Quality
Cultural Practices/Production Patterns/Pesticide Use
Ag Decision Component
Sector
Market
Regional
Firm Simulator
Firm
Biogeophysical Component
Plant
Groundwater
Surface Water
Atmosphere
Yields/Pesticide Fate/Erosion
Pesticides Use Levels/Acreages Treated Production of Treated Commodities
Chemical Sediment Fate
Health and Environment Fate
Health & Environment Risk Component
Drinking Water
Food
Air
Applicator

---

* SOURCE: CEPPES.

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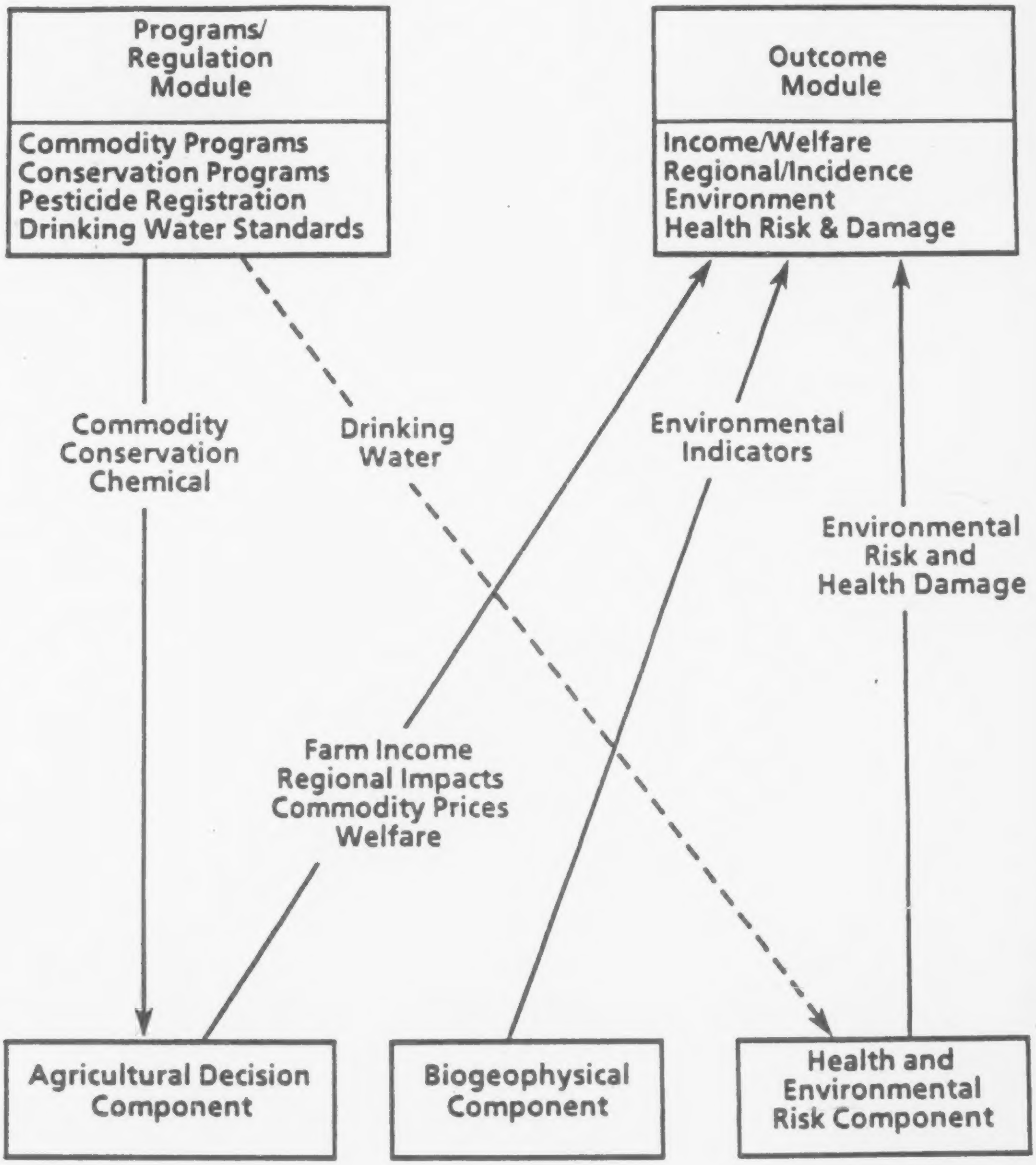
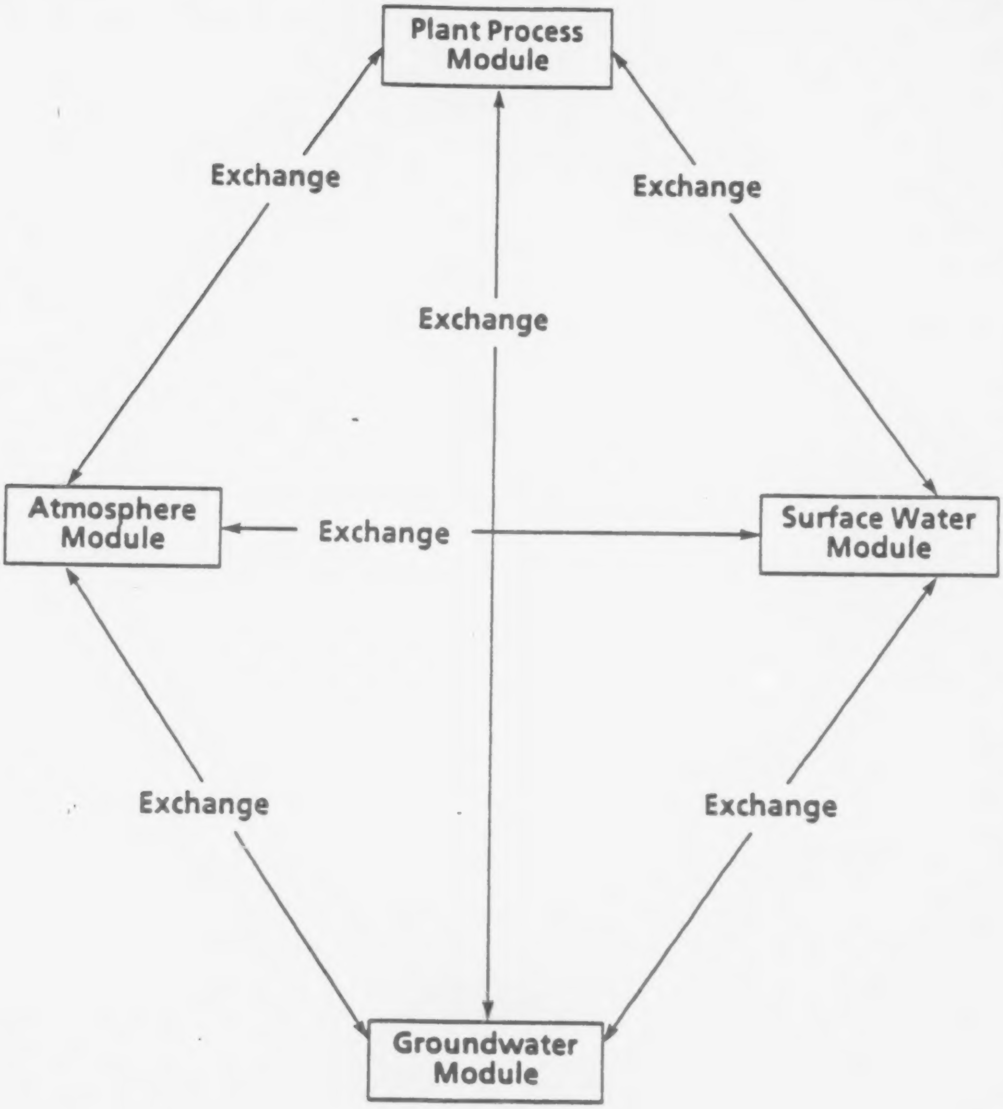
Figure 51. The policy components of CEPPES*.


Programs/ Regulation Module
Commodity Programs
Conservation Programs
Pesticide Registration
Drinking Water Standards
Outcome Module
Income/Welfare
Regional/Incidence
Environment
Health Risk & Damage
Commodity Conservation Chemical
Drinking Water
Environmental Indicators
Environmental Risk and Health Damage
Farm Income Regional Impacts Commodity Prices Welfare
Agricultural Decision Component
Biogeophysical Component
Health and Environmental Risk Component

---

[*] SOURCE: CEPPES.

Figure 52. The biogeophysical components of CEPPES*.


Plant Process Module
Exchange
Exchange
Exchange
Atmosphere Module
Exchange
Surface Water Module
Exchange
Exchange
Groundwater Module

---

[*] SOURCE: CEPPES.

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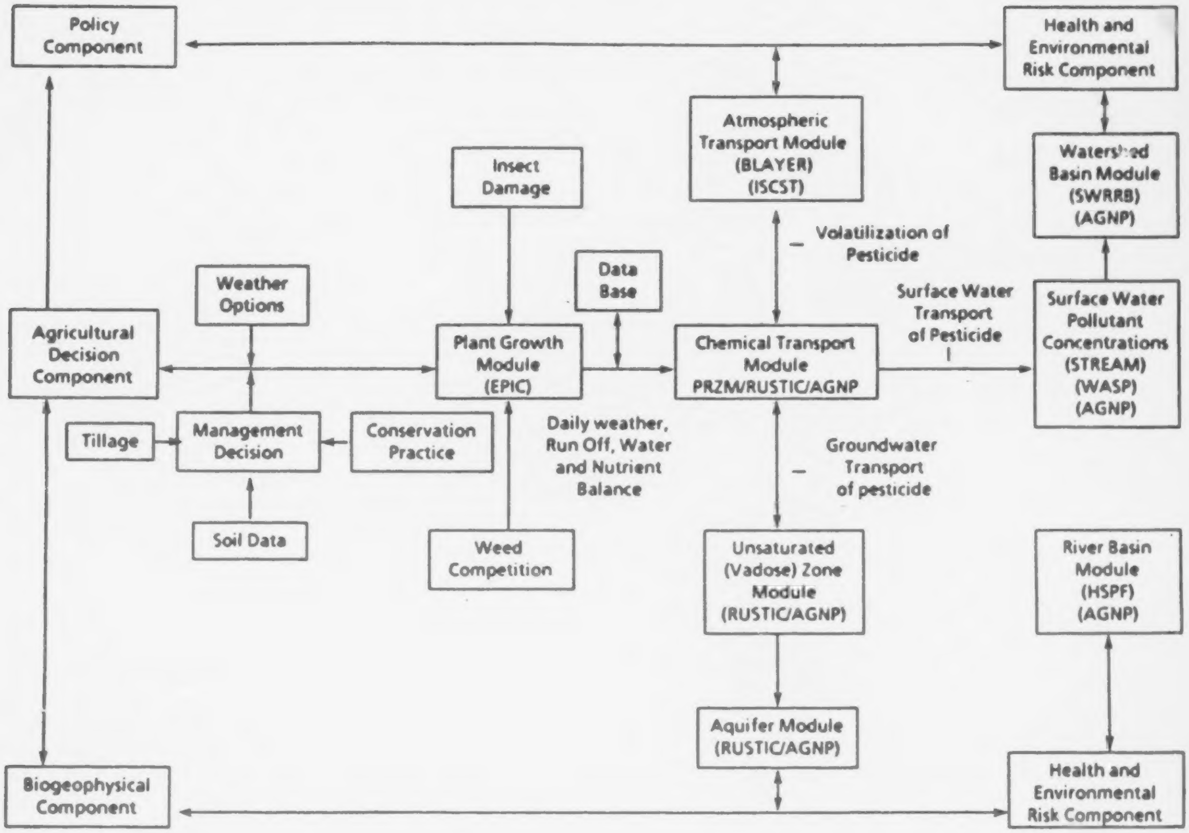
Figure 53. Diagram of the modules to be used in the biogeophysical component of CEPPES*.


Policy Component
Health and Environmental Risk Component
Atmospheric Transport Module (BLAYER) (ISCST)
Watershed Basin Module (SWRRB) (AGNP)
Insect Damage
Volatilization of Pesticide
Data Base
Weather Options
Surface Water Transport of Pesticide
Surface Water Pollutant Concentrations (STREAM) (WASP) (AGNP)
Agricultural Decision Component
Plant Growth Module (EPIC)
Chemical Transport Module PRZM/RUSTIC/AGNP
Tillage
Management Decision
Conservation Practice
Daily weather, Run Off, Water and Nutrient Balance
Groundwater Transport of pesticide
Soil Data
Weed Competition
Unsaturated (Vadose) Zone Module (RUSTIC/AGNP)
River Basin Module (HSPF) (AGNP)
Aquifer Module (RUSTIC/AGNP)
Biogeophysical Component
Health and Environmental Risk Component

---

* SOURCE: CEPPES.

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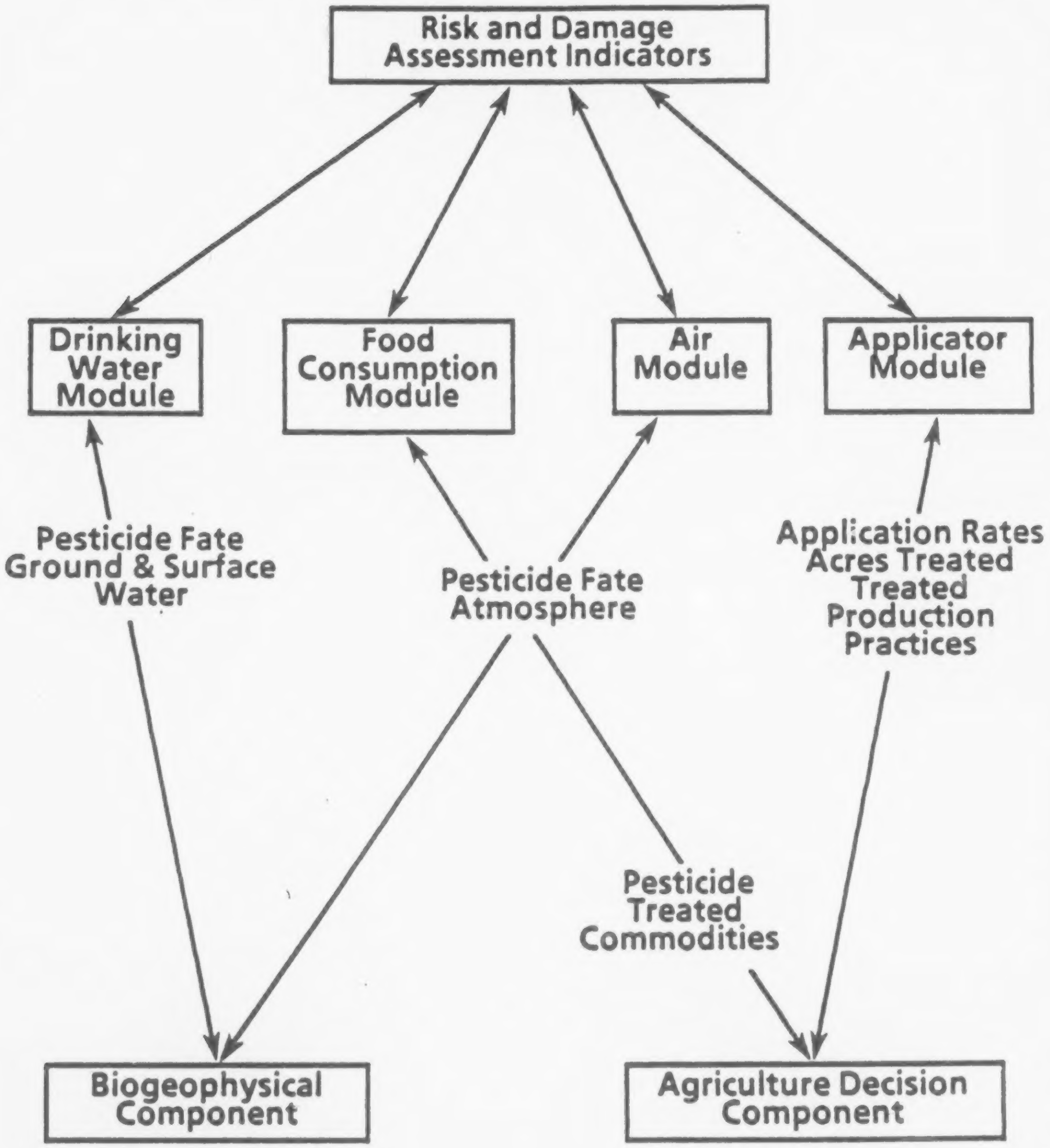
Figure 54. Linkage between health and environment risk component and biogeophysical and agricultural decision components of CEPPES*.


Risk and Damage Assessment Indicators
Drinking Water Module
Food Consumption Module
Air Module
Applicator Module
Pesticide Fate Ground & Surface Water
Pesticide Fate Atmosphere
Application Rates Acres Treated Treated Production Practices
Pesticide Treated Commodities
Biogeophysical Component
Agriculture Decision Component

---

* SOURCE: CEPPES.

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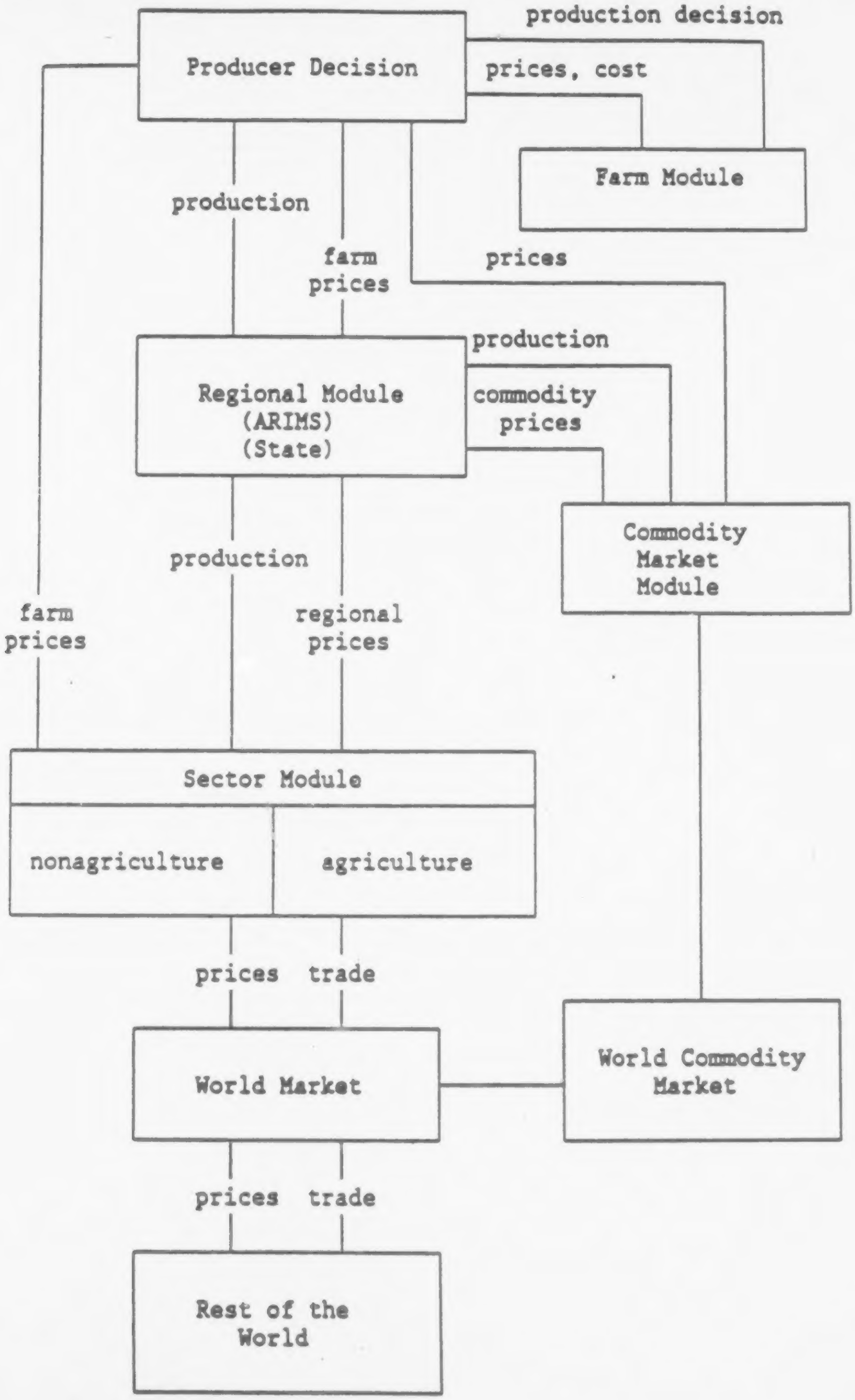
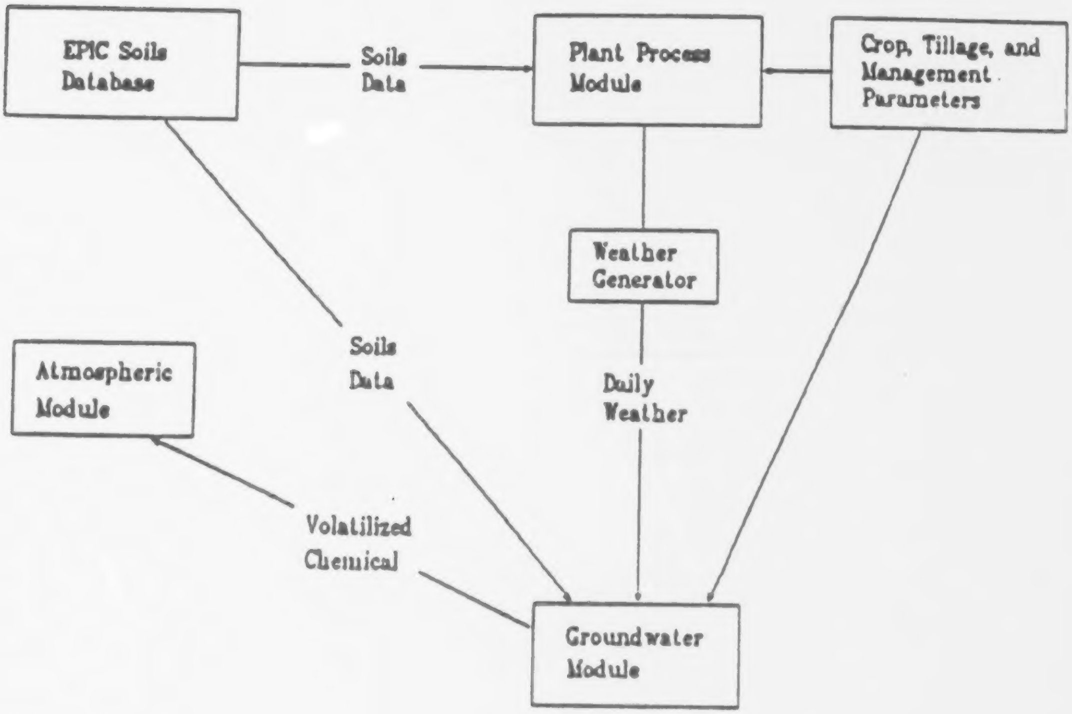
Figure 55. Key linkages of modules of the agricultural decision component*.


production decision
Producer Decision
prices, cost
Farm Module
production
farm prices
prices
production
Regional Module (ARIMS) (State)
commodity prices
Commodity Market Module
production
farm prices
regional prices
Sector Module
nonagriculture
agriculture
prices
trade
World Market
World Commodity Market
prices
trade
Rest of the World

---

* SOURCE: CEPPES.

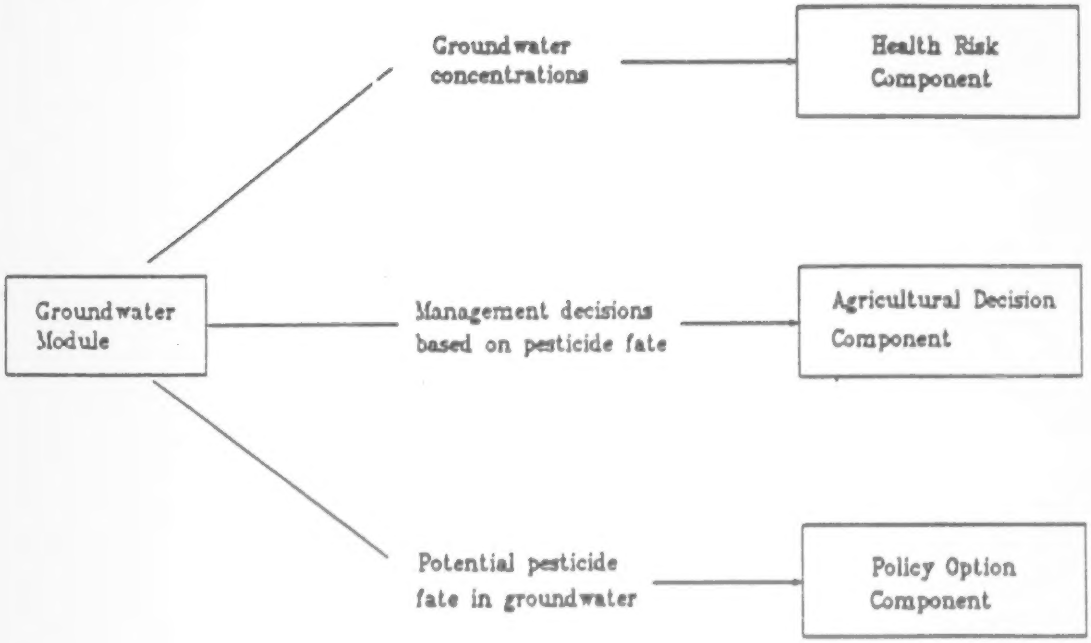
Figure 56. Current linkages between plant process and groundwater modules of the biogeophysical component*.


EPIC Soils Database
Soils Data
Plant Process Module
Crop, Tillage, and Management Parameters
Weather Generator
Soils Data
Atmospheric Module
Daily Weather
Volatilized Chemical
Groundwater Module

---

* SOURCE: CEPPES.

Figure 57. Groundwater module linkages with other components of CEPPES*.


Groundwater Module
Groundwater concentrations
Health Risk Component
Management decisions based on pesticide fate
Agricultural Decision Component
Potential pesticide fate in groundwater
Policy Option Component

---

* SOURCE: CEPPES.

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Figure 58. A complete information and decision management system

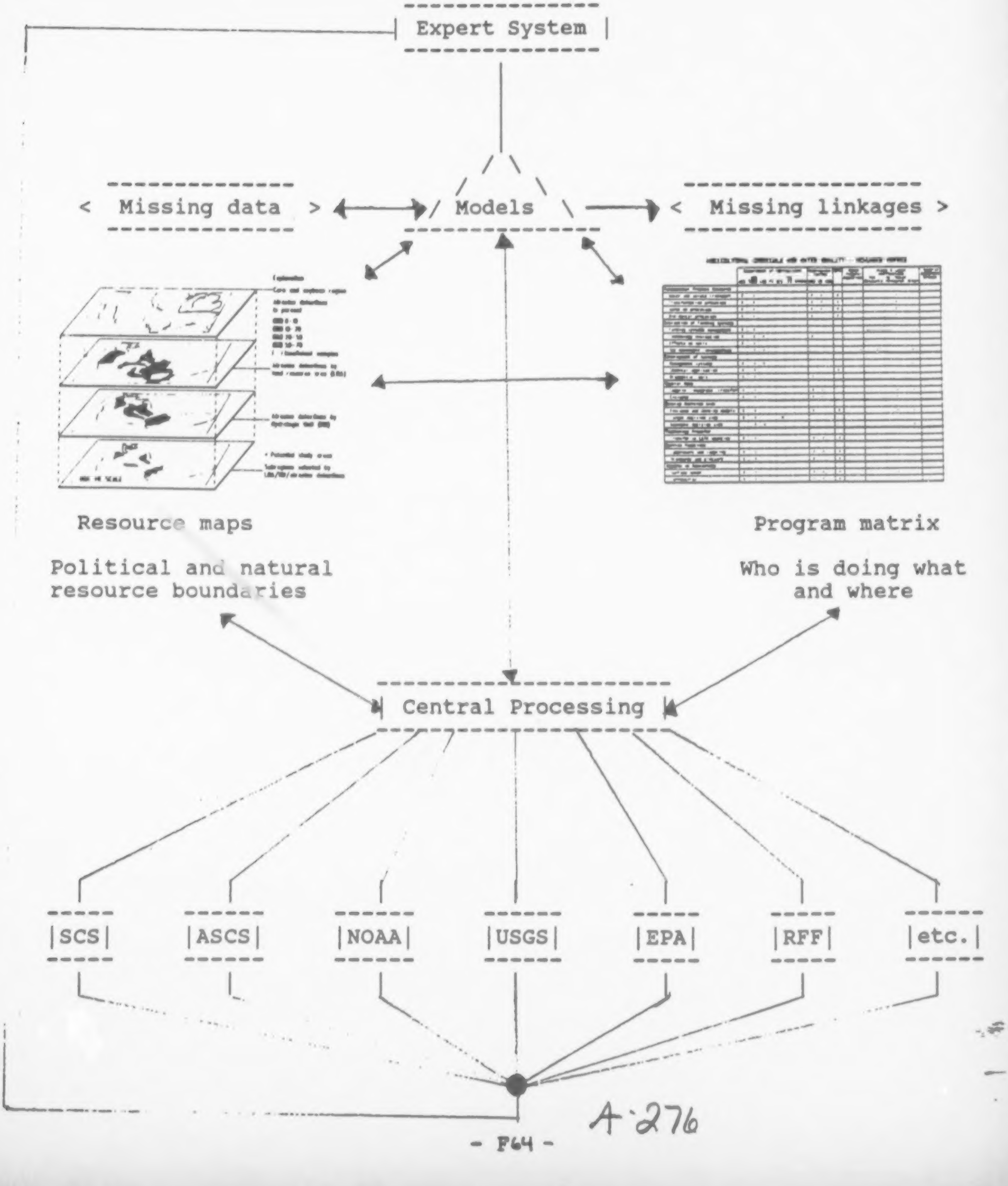
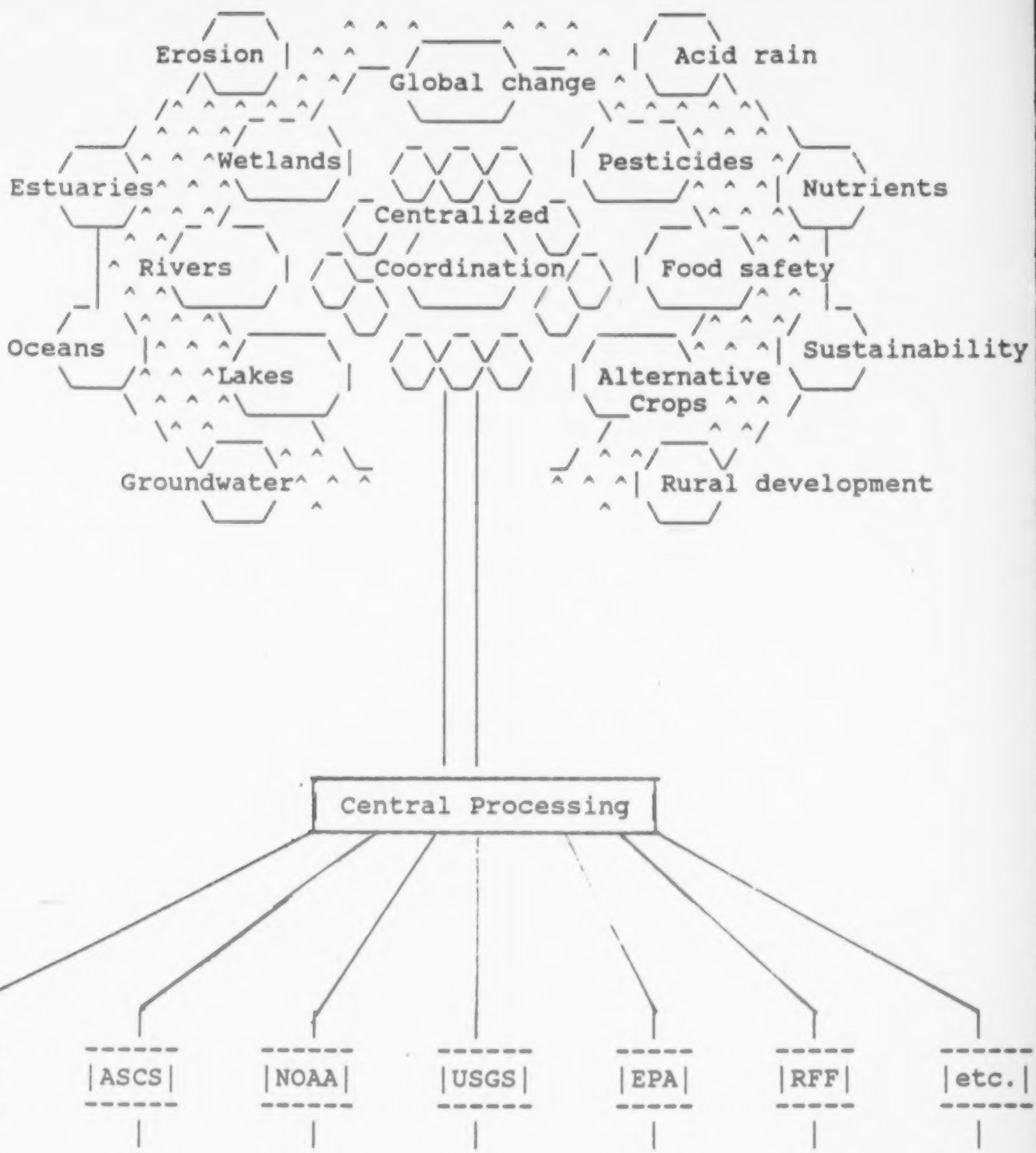

Expert System
Missing data
Models
Missing linkages
Resource maps
Political and natural resource boundaries
Program matrix
Who is doing what and where
Central Processing
SCS
ASCS
NOAA
USGS
EPA
RFF
etc.

Figure 59. The "dandelion model" of global environment management


Erosion
Global change
Acid rain
Estuaries
Wetlands
Pesticides
Nutrients
Centralized
Rivers
Coordination
Food safety
Oceans
Lakes
Alternative Crops
Sustainability
Groundwater
Rural development
Central Processing
SCS
ASCS
NOAA
USGS
EPA
RFF
etc.

VI. LITERATURE

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THE FEDERAL ROLE IN REDUCING AGRICHEMICAL CONTAMINATION OF GROUNDWATER: APPENDICES A-I

by

Laura A. Dye

December 1989

This contractor document was prepared for the Office of Technology Assessment (OTA) assessment entitled Beneath the Bottom Line: Agricultural Approaches to Reduce Agrichemical Contamination of Groundwater. It is being made available because they contain useful information beyond that used in the OTA report. However, they are not endorsed by OTA, nor have they been reviewed by the Technology Assessment Board. References to them should cite the contractor, not OTA, as the author; a suggested citation format follows:

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APPENDIX A: THE FEDERAL APPROACH TO REDUCING AGRI-CHEMICAL CONTAMINATION OF GROUNDWATER

Ground water--once thought to be ever pure and vastly abundant--supplies over 50 percent of the nation (approximately 117 million people) with potable water. However, since the early 1960's, agri-chemical contaminants have been detected with increasing frequency; every state is now reporting some degree of contamination.[59]

Evolving Issues Impacting on Ground Water

During the course of the assessment, Agricultural Approaches to Reduce Agri-Chemical Contamination of Groundwater, several new concerns were identified. Those concerns were threefold: a correlation exists between pesticide and nitrate contamination of ground water, and an increased incidence of certain cancers; siltation and nutrient loading are the leading cause of use impairment in lakes, rivers, estuaries, streams and coastal waters; and significant amounts of pesticides are applied to the environment by the suburban homeowner, who is unlicensed, uneducated, and unregulated on their proper use.

Cancer. Correlating cancer mortality data with agricultural chemical use, a study by Stokes and Brace (1986), found "agricultural chemical use was the best predictor of cancer mortality, for three of the five categories of cancer included."[57] (Note: Based on pesticide exposer to the applicator.)

Findings from a similar study conducted by Weisenberger et al. (1985) suggested "that the increased incidence and abnormal distribution of non-hodgkin's lymphoma (NHL) in eastern Nebraska may be related to intense use of nitrogen fertilizers and resultant groundwater contamination."[68] More recently, ongoing studies by Weisenberger have determined that atrazine (the most widely used corn herbicide in the U.S.) and nitrite (a metabolite of introduced soil nitrates) form a N-nitroso-atrazine (NNAT) at an acid (soil) pH. Though further study is needed, NNAT has been found to be a carcinogen.[68]

Surface Water. Nationally, "siltation affects about 42 percent of impaired river/stream miles and about 49 percent of impaired lake acres while nutrients affect about 25 percent of impaired river/stream miles and about 49 percent of impaired lake acres. The States rank agriculture fourth among the pollution sources associated with fishing restrictions. Agriculture is the most commonly reported source of fish kills (in particular, runoff from animal holding areas and feedlots; and the application of fertilizers)."[47]

Suburban Pesticide Use. Based on a 1979 National Academy of Science (NAS) study, Table 3.2 (below) depicts the amount of pesticide use in the U.S. in thousands of pounds of active ingredients.[11] In this table, home and garden use of pesticides is not the most dramatic--but indeed significant. Whereas, farmers are required by law to undergo pesticide applicator training at the state level (though degree of difficulty and depth of training are variable from state to state);[28] the suburban homeowner receives no such training in the proper use of pesticides.

TABLE 3.2 Estimated Farm and Nonfarm Uses of Pesticides in the United States in 1979, by Quantities[a]

Use	Insecticides[b]	Herbicides[c]	Fungicides[d]	Other[e]	Total
Farm uses	302,400	448,000	37,100	53,000	840,500
Nonfarm uses					
Industrial/ Commercial/ Government	37,800	84,000	58,300	42,400	222,500
Home & garden	37,800	28,000	10,600	10,600	87,000
Subtotal	75,600	112,000	68,900	53,000	309,500
Total:	378,000	560,000	106,000	106,000	1,150,000

[a] All quantities reported in thousands of pounds of active ingredients.

[b] Includes miticides and contact nematicides.

[c] Includes plant growth regulators.

[d] Does not include wood preservatives.

[e] Includes rodenticides, fumigants, and molluscicides.

SOURCE: U.S. EPA (1979d), based on National Agricultural Chemicals Association annual surveys and U.S. International Trade Commission data.

> A separate case study by Von Rumker et al. (1972), evaluated pesticide use within three selected metropolitan areas: Philadelphia; Dallas; and Lansing, Michigan. The study determined that "on an area basis homeowners applied from 5.3 to 10.6 lbs of pesticide per acre, suggesting that suburban lawns and gardens receive heavier pesticide applications than most other land areas in the United States."[11]

However, the focus of this Report was to determine the amount of Federal involvement in protection, remediation, and mitigation of ground water from agricultural-chemical contamination. The scope and extent of involvement was to be determined by the agencies, and where possible--for the decade, 1980-1990--the amount of base funding applied to and the number of full-time equivalents being directed toward this activity were to be ascertained. The following agencies were reviewed:

USACE	U.S. ARMY CORPS OF ENGINEERS
CECW	Directorate of Civil Works
	EXECUTIVE OFFICES OF THE PRESIDENT
CEQ	Council on Environmental Quality
OMB	Office of Management and Budget
OPD	Office of Policy Development
OSTP	Office of Science and Technology Policy
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
APHIS	Animal and Plant Health Inspection Service
ARS	Agricultural Research Service
ASCS	Agricultural Stabilization and Conservation Service
CSRS	Cooperative State Research Service
ECONOMICS	Assistant Secretary Economics
ERS	Economic Research Service
ES	Extension Service
FmHA	Farmers Home Administration
FS	Forest Service
IACP	Assistant Secretary International Affairs and Commodity Programs

M & IS	Assistant Secretary Marketing and Inspection Services
NAL	National Agricultural Library
NASS	National Agricultural Statistics Service
NR & E	Assistant Secretary Natural Resources and Environment
S & E	Assistant Secretary Science and Education
SCRD	Assistant Secretary Small Community and Rural Development
SCS	Soil Conservation Service
USEPA	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OA&R	Assistant Administrator for Air and Radiation
OARD	Assistant Administrator for Research and Development
OARM	Assistant Administrator for Administration and Resources Management
OEA	Assistant Administrator for External Affairs
OECM	Assistant Administrator for Enforcement and Compliance Monitoring
OPPE	Assistant Administrator For Policy, Planning, and Evaluation
OPTS	Assistant Administrator for Pesticides and Toxic Substances
OSWER	Assistant Administrator for Solid Waste and Emergency Response
ORD	Assistant Administrator for Research and Development
OW	Assistant Administrator for Water
USDOI	UNITED STATES DEPARTMENT OF THE INTERIOR
BIA	Bureau of Indian Affairs
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
FWS	Fish and Wildlife Service
NPS	National Park Service
USGS	United States Geological Survey
TVA	TENNESSEE VALLEY AUTHORITY
NFDC	National Fertilizer Development Center

Methodology

Because agri-chemical (nonpoint-source) contamination of ground water is an issue that cannot be clearly delineated from other forms of ground-water contamination, the agencies were asked "to interpret" what aspects of ongoing programs, budgets, and personnel resources support ground-water protection and clean-up.

Federal agencies approach ground-water resources quite differently. Yet, the common objective in all Federal ground-water programs is the improvement in water quality; therefore, **WATER QUALITY** is defined--for the purposes of this document--as the summation of all program elements within an agency's ongoing agenda that impact (directly or indirectly) on the maintenance or enhancement of water quality. Using this definition allowed for various water resources and geologic elements to be included. From there, various agricultural elements (such as research, education, and training) and environmental-protection elements (monitoring, remediation, and mitigation) were added to form the basis of Table 1: Base Funding for Water Quality.

Tables. Because ground water is a comprehensive issue cross-cutting agency lines with many contaminant influences other than agri-chemical, budgetary dollars for agri-chemical contamination is extremely difficult to identify. For the most part, identifying portions of their budgets having "water-quality elements" as this study defines it, was not easy for the agencies; simply put, they do not earmark funds by issue.

However, with the aid of generous budgetary staffs, base funding (and supporting full-time equivalents) for **Water Quality** were determined for four agencies: Tennessee Valley Authority, United States Department of Agriculture, United States Geological Survey, and the Environmental Protection Agency.

There are eight tables depicting the following:

Table 1	Water Quality Base Funding
Table 2	Adjusted Water Quality Funding
Table 3	Water Quality Personnel Resources
Table 4	Percentage of Adjusted Funding Directed to Water Quality
Table 5	Percentage of Total Personnel Assigned to Water Quality
Table 6	Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality
Table 7	Relationship of Adjusted Total Funding to Total Personnel
Table 8	Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person (for the agency)

** To offset inflationary effects, Tables 2, 4 and 6 have been adjusted (to depict constant dollars) using 1982 GNP deflator index values.[15] Regarding tables 3, 5, and 7: it is important to note that 1980 and 1981 full-time equivalents (FTE's) are estimates; FTE's were not in use prior to 1982.

** Additionally, when reviewing the graphs, the reader should pay careful attention to the y-scale; significant differences in y values may exist between agencies represented side-by-side.

** To maintain consistency, 1990 funding and personnel values for the agencies are the President's Budget Request; however, budgetary hearings (August, 1989) may significantly affect these values.

** Tables 6 and 7 are represented to provide the reader the basis of the ratio values depicted in Table 8. The purpose of the ratio in Table 8 is to compare water-quality budgetary spending to overall budgetary allocations for each agency. Ratios whose value equals one represent comparable allocations to water-quality; values less than one represent an unequal distribution of funds to water-quality.

APPENDIX B: U. S. ARMY CORPS OF ENGINEERS

The U.S. Army Corps of Engineers (USACE) owns and operates over 600 water-control projects throughout the United States.[10] Authorization and site-specific regulation of each water-control project--primarily consisting of locks, dams, and reservoirs--are provided by authorization legislation for the purposes of flood control; navigation; hydropower; fish and wildlife preservation; and water-quality management. Corps projects, both their water-control and water-quality management, are the responsibility of the Directorate of Civil Works (CECW).

As an aid to water-quality-management decision-making, monitoring of both surface- and ground-water is ongoing within CECW's divisions and districts (Figure 1). As a result, many districts within CECW have been evaluated and determined to have sites with nonpoint-source-contamination problems. The Corps' "course of action" for those sites is the following:[38]

1. Louisville District (Kentucky). The United States Geological Survey, the Corps, and other agencies are involved in the National Water Quality Assessment Program for the Kentucky River Basin Pilot Study.

2. Nashville District (Tennessee). Many representatives of both state and federal agencies, along with the Corps, are participating in a Lake Management Advisory Group for Center Hill Lake. The Advisory Group is requiring a survey be conducted to document the effects of nutrient loading on the lake.

   To aid the State of Tennessee in developing plans for nonpoint-source-pollution control (NPS) in accordance with Section 316 of the 1987 Water Quality Act, the Nashville District has been participating in a local water quality task force. A draft report of their findings and recommendations has been released for public comment.

However, authorization does not mean appropriation; to date, no funding exists for implementing those NPS pollution-control plans developed by the States.

3. Omaha District (Nebraska). "Accelerated urbanization has increased sediment and nutrient loads to Cherry (CO), Chatfield (CO), Bear (CA), and Papillion (NE) Creek reservoirs. Degradation in water quality is particularly evident at Cherry Creek Lake; the District is coordinating with local officials to develop control measures."[10] Additionally, Omaha District has provided assistance to both the State of Nebraska, in development and implementation of nonpoint-source-pollution-control measures; and the Environmental Protection Agency's Clean Lakes Program sponsors, in implementation of Section 315 of the 1987 Water Quality Act.

   As part of district activities, Omaha District conducted a pesticide survey and determined that both Salt Valley and Papillon Creek Tributary projects have detectable levels of dieldrin, chlordane, and DDT (though at levels below those set by the Food and Drug Administration).

4. Tulsa District (Oklahoma). A Corps' study has revealed significant problems with nutrient loading at Tenkiller Lake resulting in decreased clarity and persistent algal blooms.

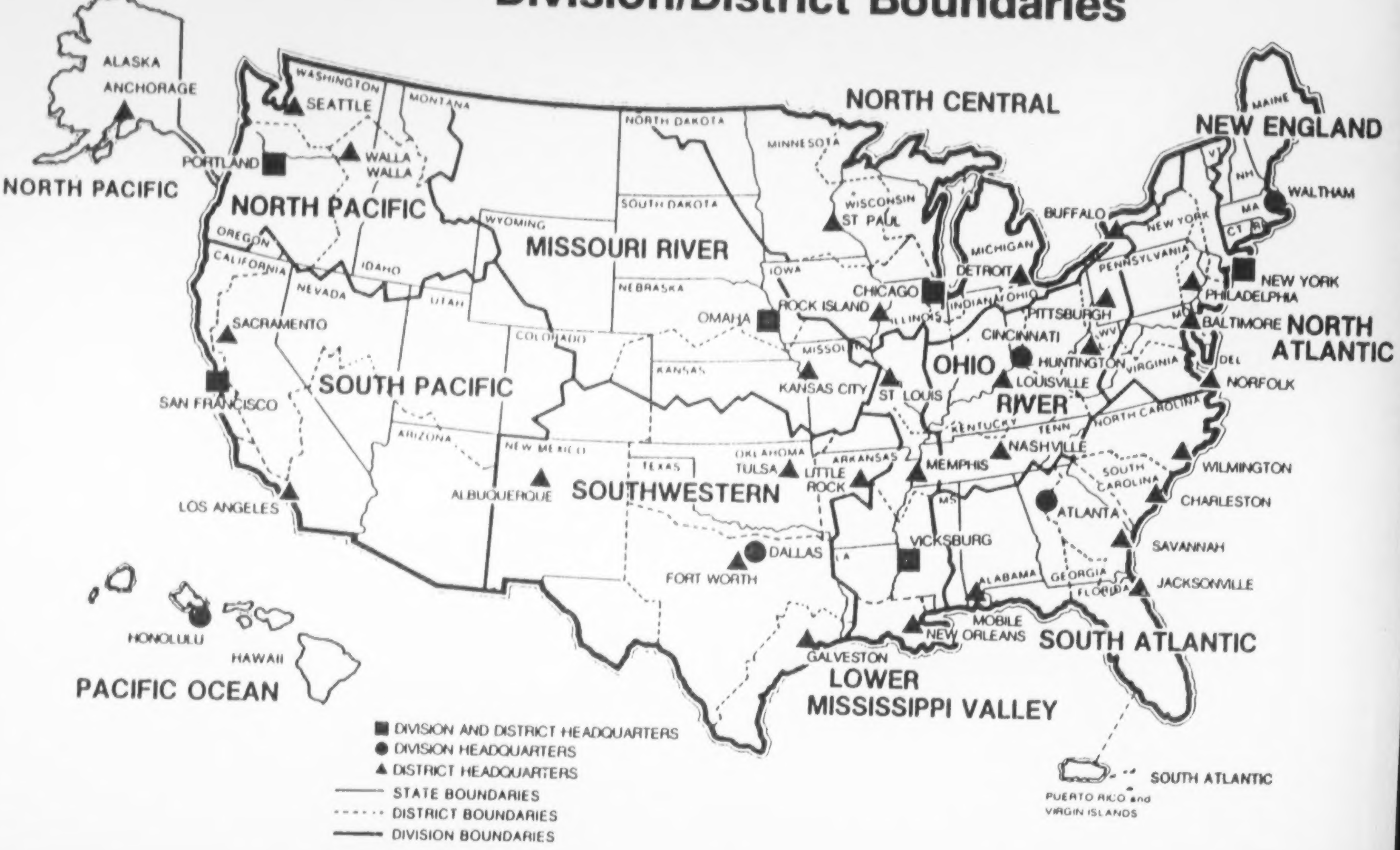
5. Kansas City District (Missouri). An analysis of both soil and water samples from NPS contamination revealed atrazine to be prevalent at all Corps project sites in significant concentrations. Other non-Corp studies, evaluating pesticide levels in fish flesh for the region, have detected the presence of dieldrin, heptachlor, and chlordane (as well as PCB's from industrial wastes). Because chlordane concentrations have been detected beyond the safe limit set by the FDA, health advisories have been issued to prevent consumption of fish from Smithville Lake.

Existing Memoranda of Understanding between CECW districts, for soil and water sampling, and the Tennessee Valley Authority (TVA), for soil- and water-sample analysis, further demonstrates the CECW's noteworthy involvement with water-quality pollution

Figure 1:

Source: United States Army Corps of Engineers, HQ
Washington D.C.

Civil Works
Division/District Boundaries


ALASKA
ANCHORAGE
NORTH PACIFIC
PORTLAND
WASHINGTON
SEATTLE
WALLA WALLA
MONTANA
NORTH PACIFIC
OREGON
CALIFORNIA
IDAHO
NEVADA
UTAH
SACRAMENTO
SAN FRANCISCO
SOUTH PACIFIC
LOS ANGELES
ARIZONA
NEW MEXICO
ALBUQUERQUE
WYOMING
MISSOURI RIVER
COLORADO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OMAHA
KANSAS CITY
MISSOURI
IOWA
ROCK ISLAND
MINNESOTA
WISCONSIN
ST PAUL
NORTH CENTRAL
CHICAGO
ILLINOIS
DETROIT
MICHIGAN
BUFFALO
INDIANA
OHIO
ST LOUIS
TEXAS
OKLAHOMA
TULSA
LITTLE ROCK
ARKANSAS
SOUTHWESTERN
DALLAS
FORT WORTH
GALVESTON
LA
VICKSBURG
MS
MEMPHIS
LOWER MISSISSIPPI VALLEY
NEW ORLEANS
MOBILE
ALABAMA
GEORGIA
FLORIDA
ATLANTA
SOUTH CAROLINA
CHARLESTON
SAVANNAH
JACKSONVILLE
WILMINGTON
SOUTH ATLANTIC
NASHVILLE
TENN
KENTUCKY
LOUISVILLE
CINCINNATI
HUNTINGTON
OHIO RIVER
WV
PITTSBURGH
PENNSYLVANIA
NEW YORK
VIRGINIA
NORTH CAROLINA
NORFOLK
DEL
MD
BALTIMORE
PHILADELPHIA
NEW YORK
NORTH ATLANTIC
VT
NH
MA
CT
RI
MAINE
WALTHAM
NEW ENGLAND
HONOLULU
HAWAII
PACIFIC OCEAN
SOUTH ATLANTIC
PUERTO RICO and VIRGIN ISLANDS
■ DIVISION AND DISTRICT HEADQUARTERS
● DIVISION HEADQUARTERS
▲ DISTRICT HEADQUARTERS
STATE BOUNDARIES
DISTRICT BOUNDARIES
DIVISION BOUNDARIES

control management. However, because CECW's water-quality activities are considered to be normal operating costs and not a separate budget item, the expense and personnel resources necessary for such water-quality activities are not readily identifiable.

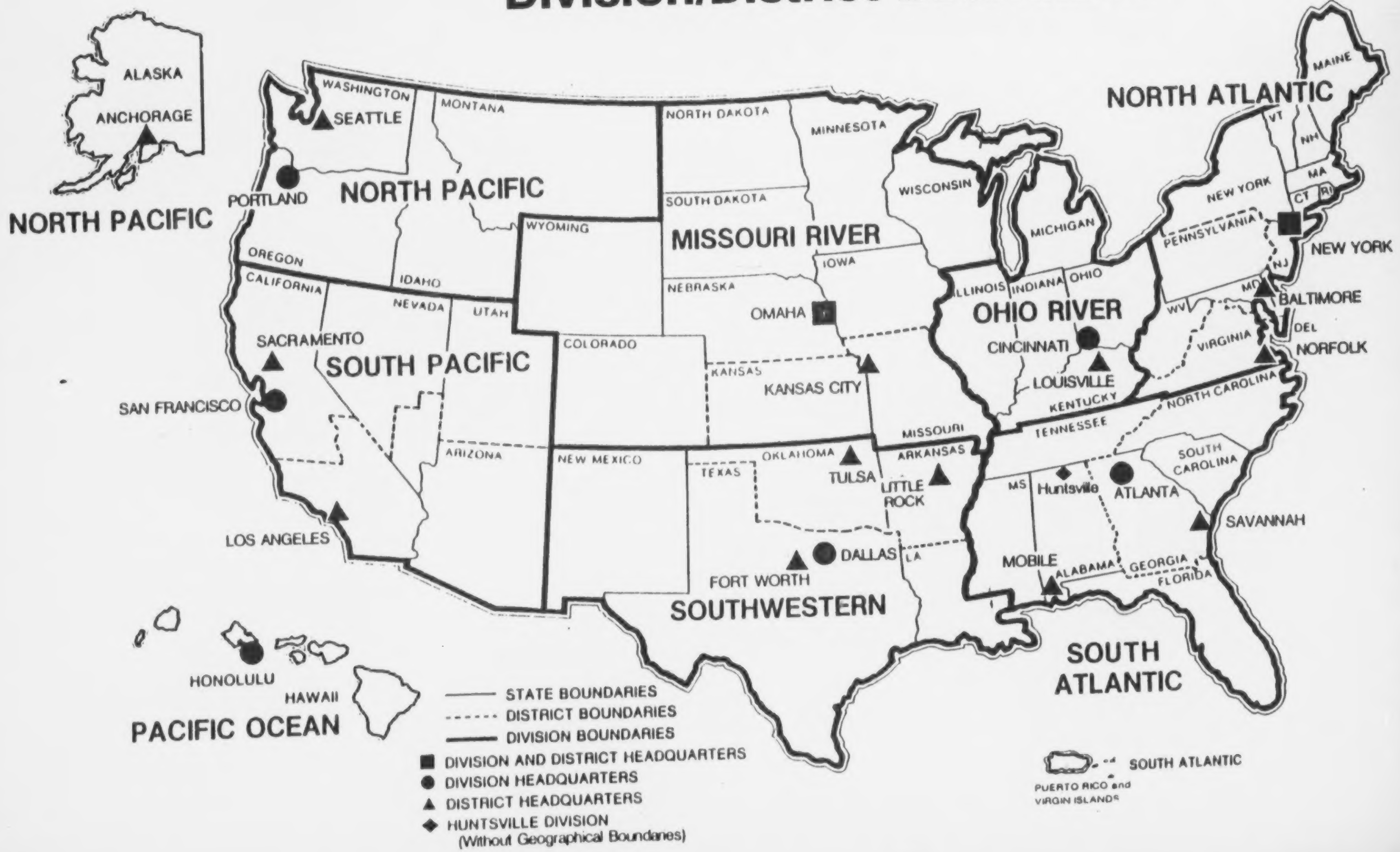
Another arm of the Corps involved in water-quality management activities is the Military Construction Districts (Figure 2). In accordance with Environmental Impact Statements (EIS's) required by EPA, military construction districts report ? all pesticide use on Army property (including all pesticide use on property leased by the Corps to farmers). Additionally, military installations monitor, at selected sites on installation property, all point-source and nonpoint source discharges that could result in changes to surface- and ground-water quality. Furthermore, both surface- and ground-water samples are evaluated periodically.[38] As is the case with CECW, military construction districts do not itemize water-quality activities within their operating budget; therefore, the costs and personnel allocation for such activities again are not readily identifiable.

If true, data needs to be examined for possible insights.

Source: United States Army Corps of Engineers, HQ
Washington D.C.

Figure 2:

Military Construction
Division/District Boundaries


ALASKA
ANCHORAGE
NORTH PACIFIC
WASHINGTON
SEATTLE
MONTANA
PORTLAND
NORTH PACIFIC
OREGON
IDAHO
WYOMING
CALIFORNIA
NEVADA
UTAH
SACRAMENTO
SOUTH PACIFIC
SAN FRANCISCO
COLORADO
ARIZONA
NEW MEXICO
LOS ANGELES
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
MISSOURI RIVER
IOWA
NEBRASKA
OMAHA
KANSAS
KANSAS CITY
MISSOURI
OKLAHOMA
TULSA
ARKANSAS
LITTLE ROCK
TEXAS
DALLAS
FORT WORTH
LA
SOUTHWESTERN
WISCONSIN
MICHIGAN
ILLINOIS
INDIANA
OHIO
OHIO RIVER
CINCINNATI
LOUISVILLE
KENTUCKY
TENNESSEE
NORTH ATLANTIC
MAINE
VT
NH
MA
CT
RI
NEW YORK
PENNSYLVANIA
NJ
NEW YORK
MD
BALTIMORE
DEL
WV
VIRGINIA
NORFOLK
NORTH CAROLINA
SOUTH CAROLINA
MS
Huntsville
ATLANTA
SAVANNAH
MOBILE
ALABAMA
GEORGIA
FLORIDA
SOUTH ATLANTIC
HONOLULU
HAWAII
PACIFIC OCEAN
STATE BOUNDARIES
DISTRICT BOUNDARIES
DIVISION BOUNDARIES
DIVISION AND DISTRICT HEADQUARTERS
DIVISION HEADQUARTERS
DISTRICT HEADQUARTERS
HUNTSVILLE DIVISION
(Without Geographical Boundaries)
SOUTH ATLANTIC
PUERTO RICO and VIRGIN ISLANDS

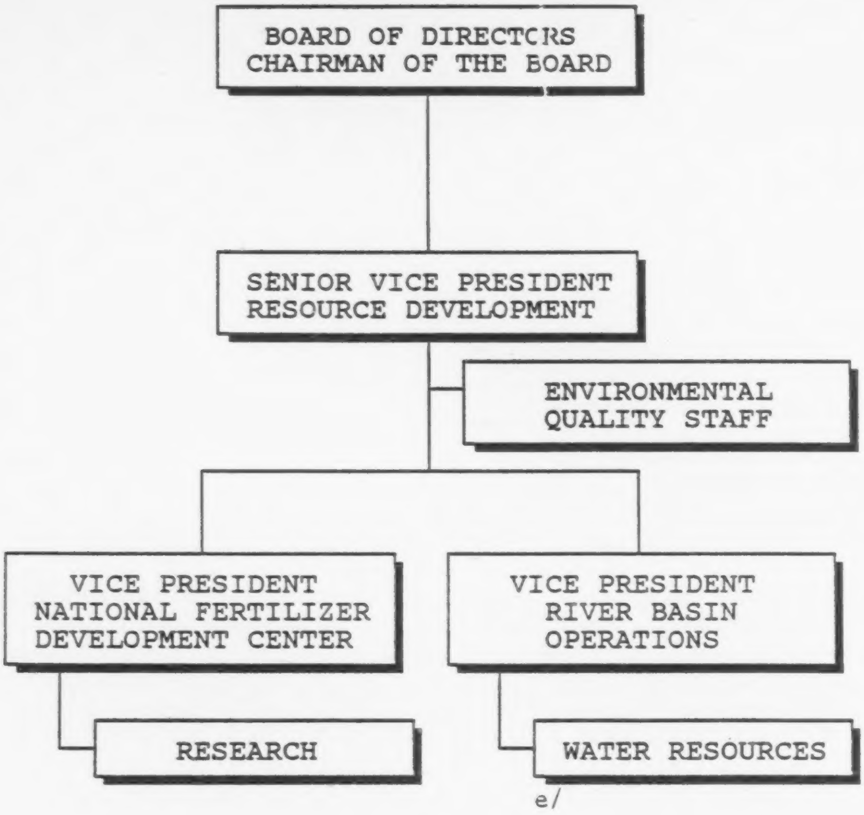
APPENDIX C: TENNESSEE VALLEY AUTHORITY

Tennessee Valley Authority (TVA): a government corporation responsible for electricity generation in a 7-state area was created by the Tennessee Valley Act (1933).[61] In the thirties, TVA constructed dams which not only supplied electricity but also ample employment to many Tennessee Valley residents; improving the quality of life in very impoverished areas of the Valley was one of TVA's major missions. Additionally, TVA began to experiment in the development of fertilizers and their agricultural uses. Still true today, TVA's National Fertilizer Development Center located in Muscle Shoals, Alabama, is the leader in fertilizer research and education.[33]

"A mixed bag"--greatly applauded for pioneering ventures in energy, agriculture, education, and industrial development--TVA also has been the target of severe environmental criticism regarding its nuclear reactors and coal generators (for exceeding water- and air-pollutant emission standards). Totally self-sustaining are TVA's power facilities; however, TVA's research and conservation programs depend on appropriated funds.

Water-quality conservation and research programs are carried out within its River Basin and National Fertilizer Development Center Operations (Figure 3, next page).

Figure 3: TENNESSEE VALLEY AUTHORITY
WATER QUALITY ORGANIZATIONAL CHART


BOARD OF DIRECTORS
CHAIRMAN OF THE BOARD
SENIOR VICE PRESIDENT
RESOURCE DEVELOPMENT
ENVIRONMENTAL
QUALITY STAFF
VICE PRESIDENT
NATIONAL FERTILIZER
DEVELOPMENT CENTER
VICE PRESIDENT
RIVER BASIN
OPERATIONS
RESEARCH
WATER RESOURCES
e/

e/ All Water Quality Personnel for River Basin Operations are located in the Water Resources Division of the Natural Resources Division.

River Basin Operations

Water Resources

Watershed Water Quality is TVA's nonpoint-source and ground-water program. As stewards of the land, regional watershed activities lead to site-specific watershed projects involving these four phases: assessment, coordination (or implementation), local participation, and technology transfer.[67]

Environmental Chemistry Laboratory (Chattanooga, Tennessee). In October 1986, in cooperation with the Electric Power Research Institute, TVA injected nonreactive tracers into the ground water at a test site (Columbus Air Force Base, Mississippi) to better understand the movement of pollutants in an aquifer.[25] Currently, TVA is planning a second tracer experiment involving the injection of nitrates and pesticides.

National Fertilizer Development Center Operations

NFDC Research

One of TVA's missions as defined by the Tennessee Valley Authority Act was "to provide for the agricultural and industrial development" of the Valley--then suffering from serious soil erosion and low-productivity problems. TVA, in joint venture with the USDA, developed programs to resolve these problems encompassing 7-million acres of cleared land.

From a conservation perspective, these programs were very successful until the early 1960s--when Valley farmers were encouraged to increase production of protein crops such as soybeans for the world export market. Again, tremendous soil erosion problems developed as farmers extended their cropland onto marginal land. Currently back-in-check, NFDC has ongoing memoranda of agreement with USDA, EPA, and the seven States to provide farmers educational and technical assistance in order to protect the region's soil and water resources. From this interaction, *Land and Water 201 (1988-2000)*,[1] a comprehensive resource-conservation program was developed for the region. This program's

how integration
local SCS
conservation
districts?

primary objectives are 1) to reduce soil erosion 2) to enhance water quality 3) to increase farm income and 4) to be a national model of successful multi-agency cooperation for soil and water conservation.

In 1989, NFDC redefined its mission to be a "leading national source of nutrient-related information for public and private use and to target its research to high-priority environmental issues."[34] In concurrence with its Environmental Initiative are NFDC's new objectives: to research and develop new technologies to achieve containment and compliance with fertilizer-related materials, and then transfer that information to the public through education in the form of reports, conferences, published guidelines, and training programs.

TVA TABLES:

TVA water-quality funding and personnel figures were provided by Budget and Financial Services, Resource Development, and Business Operations. Please note that all personnel levels are estimates. Upward trends in the graphs, from 1985 to 1987, are a result of the onset and demise of the Jobs Bill Program.[20] Significant budget cuts during the Reagan administration and subsequent reallocation of funds resulted in the graphic trends, 1987-1988. Table 8: A ratio of one represents a fair allocation of funds to water-quality in comparison to overall operational spending (Note: see Explanatory Notes for Tables, Appendix A).

subjective
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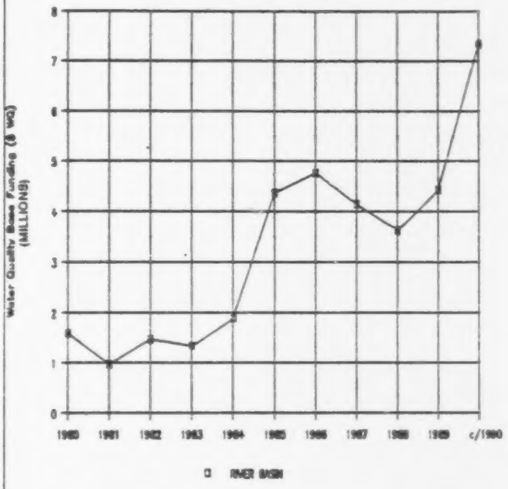
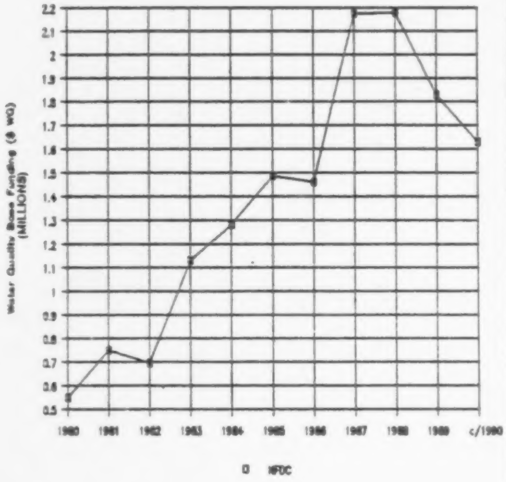
TABLE AND GRAPHS 1 OF 8:

TENNESSEE VALLEY AUTHORITY

Water Quality Base Funding for River Basin and NFDC Operations

1980–1990


RIVER BASIN OPERATIONS


NATIONAL FERTILIZER DEVELOPMENT CENTER

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin											
Operations											
NATURAL RESOURCES											
$ WQ	1,587	967	1,475	1,338	1,893	4,376	4,762	4,140	3,622	4,437	7,330
$ TOTAL	28,942	27,988	31,916	37,785	50,160	50,398	46,671	44,466	44,760	43,833	46,674
National Fertilizer Development Center Operations (NFDC)											
RESEARCH											
$ WQ	549	750	696	1,131	1,282	1,487	1,461	2,176	2,178	1,828	1,631
$ TOTAL	43,582	40,455	40,482	38,808	43,839	46,046	37,097	35,307	34,939	31,724	28,592

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

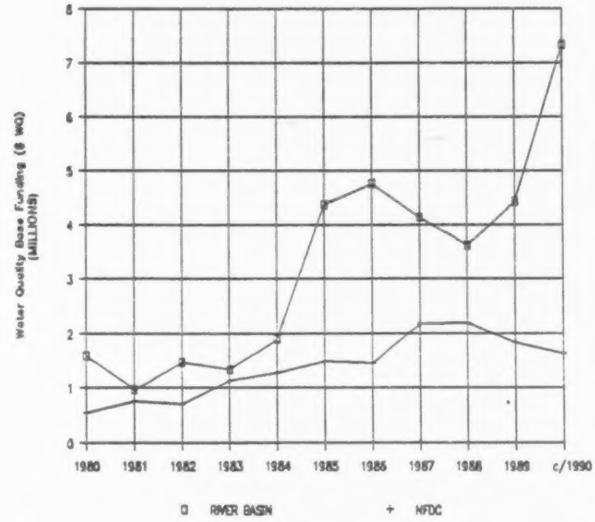
TABLE AND GRAPH 1 OF 8:

TENNESSEE VALLEY AUTHORITY

Water Quality Base Funding for River Basin and NFDC Operations

1980-1990

RIVER BASIN AND NFDC OPERATIONS



(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin Operations											
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RESEARCH											
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$ TOTAL	43,582	40,455	40,482	38,808	43,839	46,046	37,097	35,307	34,939	31,724	28,592

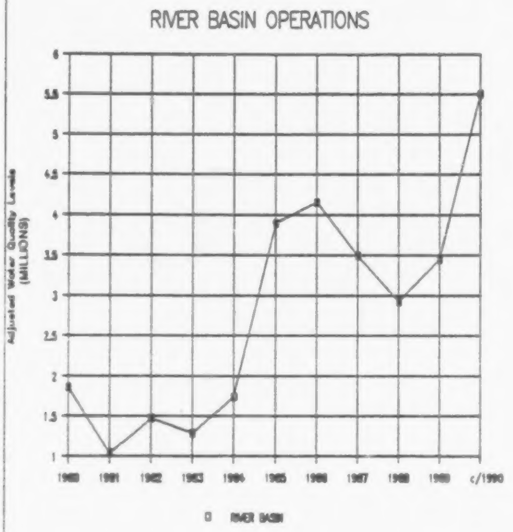
c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

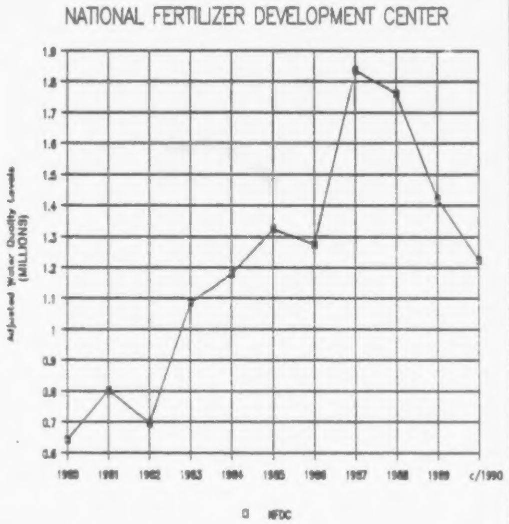
TABLE AND GRAPHS 2 OF 8:

TENNESSEE VALLEY AUTHORITY

Adjusted Water Quality Levels for River Basin and NFDC Operations

1980–1990


RIVER BASIN OPERATIONS


NATIONAL FERTILIZER DEVELOPMENT CENTER

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
1982 GNP Deflator Index Values:	0.855	0.934	1	1.04	1.086	1.123	1.146	1.185	1.237	1.286	1.332
River Basin Operations NATURAL RESOURCES											
$ WQ	1,856.1	1,035.3	1,475.0	1,286.5	1,743.1	3,896.7	4,155.3	3,493.7	2,928.1	3,450.2	5,503.0
$ TOTAL	33,850.3	29,965.7	31,916.0	36,331.7	46,187.8	44,878.0	40,725.1	37,524.1	36,184.3	34,084.8	35,040.5
National Fertilizer Development Center Operations (NFDC) RESEARCH											
$ WQ	642.1	803.0	696.0	1,087.5	1,180.5	1,324.1	1,274.9	1,836.3	1,760.7	1,421.5	1,224.5
$ TOTAL	50,973.1	43,313.7	40,482.0	37,315.4	40,367.4	41,002.7	32,370.9	29,794.9	28,244.9	24,668.7	21,465.5

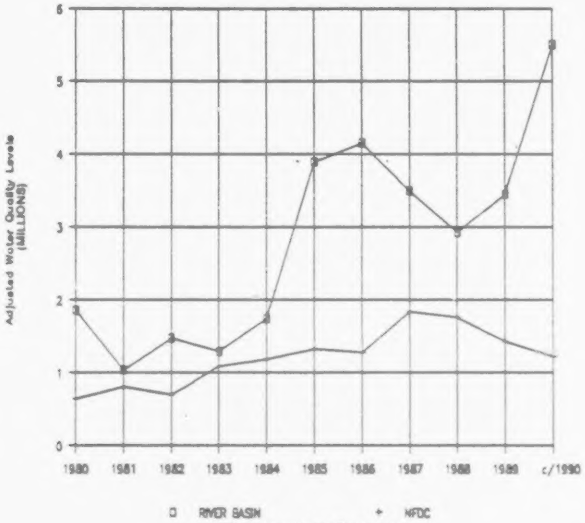
c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

TABLE AND GRAPH 2 OF 8:

TENNESSEE VALLEY AUTHORITY
Adjusted Water Quality Levels for River Basin and NFDC Operations

1980–1990

RIVER BASIN AND NFDC OPERATIONS



(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
1982 GNP Deflator Index Values:	0.855	0.934	1	1.04	1.086	1.123	1.146	1.185	1.237	1.286	1.332
River Basin Operations											
NATURAL RESOURCES											
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$ TOTAL	33,850.3	29,965.7	31,916.0	36,331.7	46,187.8	44,878.0	40,725.1	37,524.1	36,184.3	34,084.8	35,040.5
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RESEARCH											
$ WQ	642.1	803.0	696.0	1,087.5	1,180.5	1,324.1	1,274.9	1,836.3	1,760.7	1,421.5	1,224.5
$ TOTAL	50,973.1	43,313.7	40,482.0	37,315.4	40,367.4	41,002.7	32,370.9	29,794.9	28,244.9	24,668.7	21,465.5

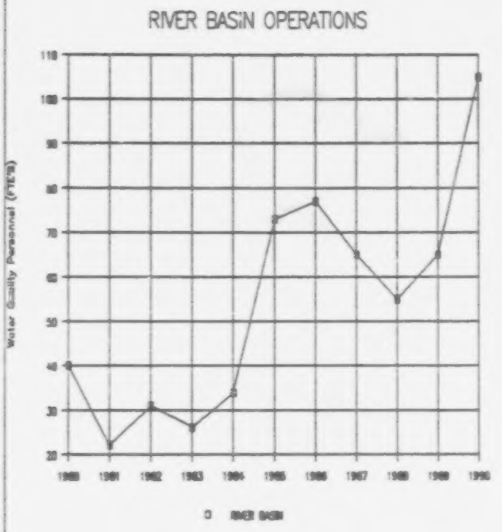
c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

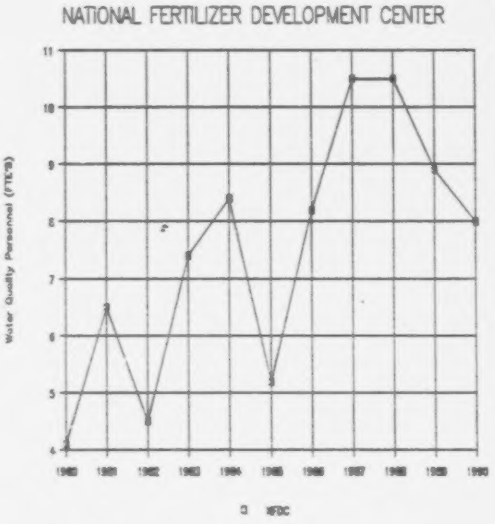
TABLE AND GRAPHS 3 OF 8:

TENNESSEE VALLEY AUTHORITY

Water Quality Personnel Resources for River Basin and NFDC Operations

1980–1990





WQ = Water Quality FTE = Full–Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
River Basin Operations NATURAL RESOURCES											
d/ FTE WQ	40	22	31	26	34	73	77	65	55	65	105
d/ FTE TOTAL	724	636	665	675	764	757	753	695	678	645	667
National Fertilizer Development Center Operations (NFDC) RESEARCH											
d/ FTE WQ	4.1	6.5	4.5	7.4	8.4	5.2	8.2	10.5	10.5	8.9	8
d/ FTE TOTAL	446.4	451.7	479.2	428.4	455.2	481.7	402.3	378.6	356	277.4	252.2

d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

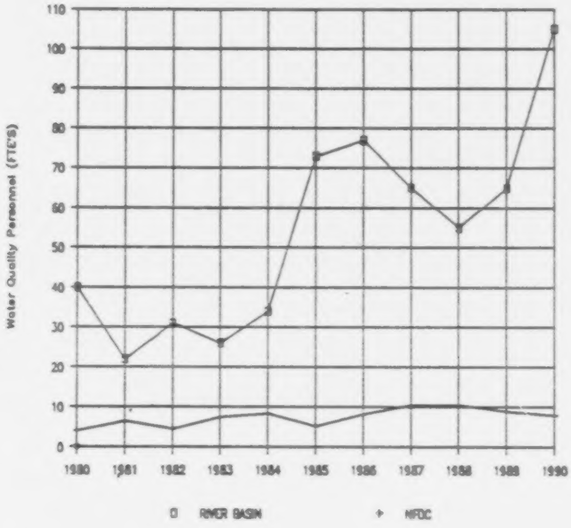
TABLE AND GRAPH 3 OF 8:

TENNESSEE VALLEY AUTHORITY

Water Quality Personnel Resources for River Basin and NFDC Operations

1980–1990

RIVER BASIN AND NFDC OPERATIONS



WQ = Water Quality FTE = Full-Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
River Basin Operations NATURAL RESOURCES											
d/ FTE WQ	40	22	31	26	34	73	77	65	55	65	105
d/ FTE TOTAL	724	636	665	675	764	757	753	695	678	645	667
National Fertilizer Development Center Operations (NFDC) RESEARCH											
d/ FTE WQ	4.1	6.5	4.5	7.4	8.4	5.2	8.2	10.5	10.5	8.9	8
d/ FTE TOTAL	446.4	451.7	479.2	428.4	455.2	481.7	402.3	378.6	356	277.4	252.2

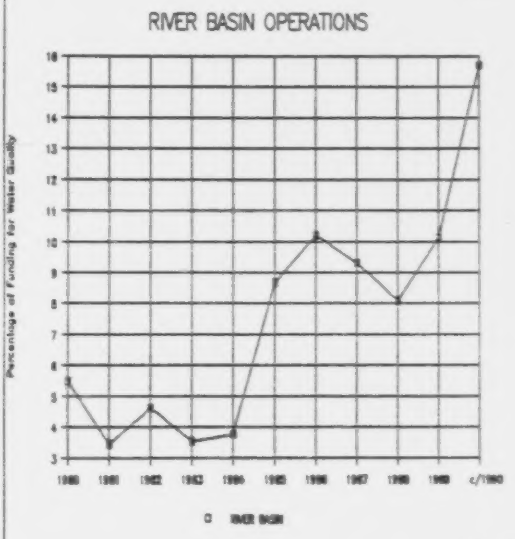
d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

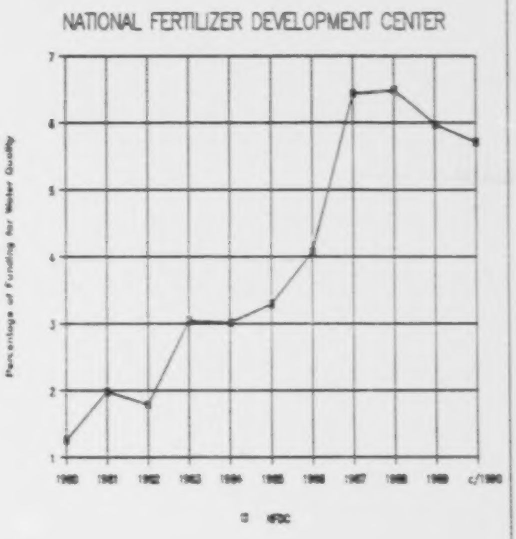
TABLE AND GRAPHS 4 OF 8:

TENNESSEE VALLEY AUTHORITY

Percentage of Adjusted Funding Directed to Water Quality for River Basin and NFDC Operations

1980–1990





(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin **Operations** **NATURAL RESOURCES**											
$ WQ	1,858.1	1,035.3	1,475.0	1,286.5	1,743.1	3,896.7	4,155.3	3,493.7	2,928.1	3,450.2	5,503.0
$ TOTAL	33,850.3	29,965.7	31,916.0	36,331.7	46,187.8	44,878.0	40,725.1	37,524.1	36,184.3	34,084.8	35,040.5
$ WQ/$ TOTAL (%)	5.5	3.5	4.6	3.5	3.8	8.7	10.2	9.3	8.1	10.1	15.7
National Fertilizer Development Center Operations (NFDC) **RESEARCH**											
$ WQ	642.1	803.0	696.0	1,087.5	1,180.5	1,324.1	1,274.9	1,836.3	1,760.7	1,421.5	1,224.5
$ TOTAL	50,973.1	40,455.0	38,925.0	35,734.8	39,037.4	40,179.8	31,305.5	28,542.4	27,168.7	23,816.8	21,465.5
$ WQ/$ TOTAL (%)	1.3	2.0	1.8	3.0	3.0	3.3	4.1	6.4	6.5	6.0	5.7

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

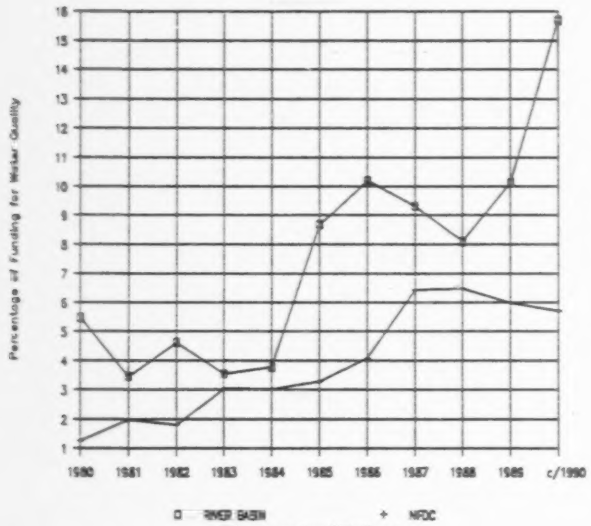
TABLE AND GRAPH 4 OF 8:

TENNESSEE VALLEY AUTHORITY

Percentage of Adjusted Funding Directed to Water Quality for River Basin and NFDC Operations

1980–1990

RIVER BASIN AND NFDC OPERATIONS



(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin Operations NATURAL RESOURCES											
$ WQ	1,856.1	1,035.3	1,475.0	1,286.5	1,743.1	3,896.7	4,155.3	3,493.7	2,928.1	3,450.2	5,503.0
$ TOTAL	33,850.3	29,965.7	31,916.0	36,331.7	46,187.8	44,878.0	40,725.1	37,524.1	36,184.3	34,084.8	35,040.5
$ WQ/$ TOTAL (%)	5.5	3.5	4.6	3.5	3.8	8.7	10.2	9.3	8.1	10.1	15.7
National Fertilizer Development Center Operations (NFDC) RESEARCH											
$ WQ	642.1	803.0	696.0	1,087.5	1,180.5	1,324.1	1,274.9	1,836.3	1,760.7	1,421.5	1,224.5
$ TOTAL	50,973.1	40,455.0	38,925.0	35,734.8	39,037.4	40,179.8	31,305.5	28,542.4	27,168.7	23,816.8	21,465.5
$ WQ/$ TOTAL (%)	1.3	2.0	1.8	3.0	3.0	3.3	4.1	6.4	6.5	6.0	5.7

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

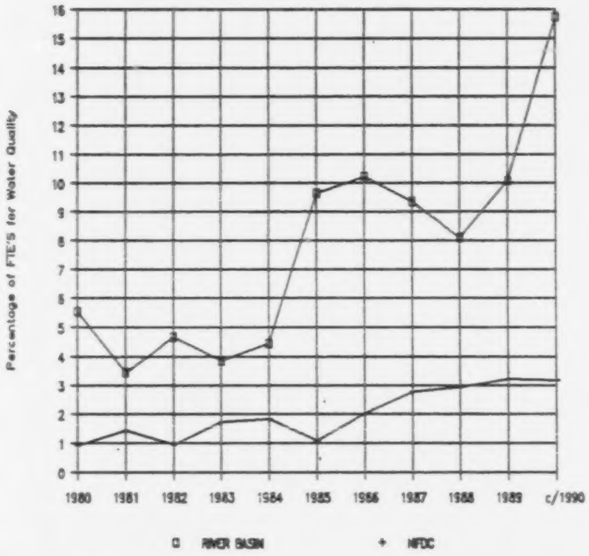
TABLE AND GRAPH 5 OF 8:

TENNESSEE VALLEY AUTHORITY

Percentage of Total Personnel Assigned to Water Quality for River Basin and NFDC Operations

1980–1990

RIVER BASIN AND NFDC OPERATIONS



WQ = Water Quality FTE = Full-Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
River Basin Operations NATURAL RESOURCES											
d/FTE WQ	40	22	31	26	34	73	77	65	55	65	105
d/FTE TOTAL	724	636	665	675	764	757	753	695	678	645	667
FTE WQ/FTE TOTAL (%)	5.5	3.5	4.7	3.9	4.5	9.6	10.2	9.4	8.1	10.1	15.7
National Fertilizer Development Center Operations (NFDC) RESEARCH											
d/FTE WQ	4.1	6.5	4.5	7.4	8.4	5.2	8.2	10.5	10.5	8.9	8
d/FTE TOTAL	446.	451.7	479.2	428.4	455.2	481.7	402.3	378.6	358	277.4	252.2
FTE WQ/FTE TOTAL (%)	0.9	1.4	0.9	1.7	1.8	1.1	2.0	2.8	2.9	3.2	3.2

d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

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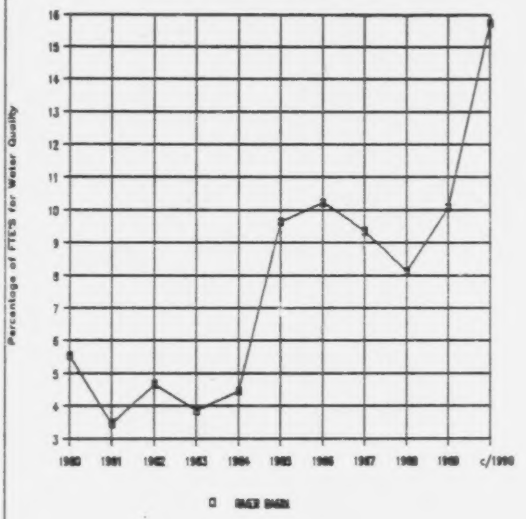
TABLE AND GRAPHS 5 OF 8:

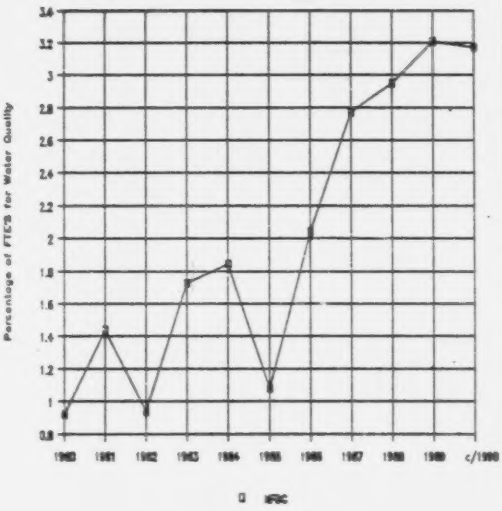
TENNESSEE VALLEY AUTHORITY

Percentage of Total Personnel Assigned to Water Quality for River Basin and NFDC Operations

1980–1990



RIVER BASIN OPERATIONS



NATIONAL FERTILIZER DEVELOPMENT CENTER

WQ = Water Quality

FTE = Full-Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
River Basin Operations NATURAL RESOURCES											
d/FTE WQ	40	22	31	26	34	73	77	65	55	65	105
d/FTE TOTAL	724	638	665	675	784	757	753	695	678	645	667
FTE WQ/FTE TOTAL (%)	5.5	3.5	4.7	3.9	4.5	9.6	10.2	9.4	8.1	10.1	15.7
National Fertilizer Development Center Operations (NFDC) RESEARCH											
d/FTE WQ	4.1	6.5	4.5	7.4	8.4	5.2	8.2	10.5	10.5	8.9	8
d/FTE TOTAL	446.4	451.7	479.2	428.4	455.2	481.7	402.3	378.6	356	277.4	252.2
FTE WQ/FTE TOTAL (%)	0.9	1.4	0.9	1.7	1.8	1.1	2.0	2.8	2.9	3.2	3.2

d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

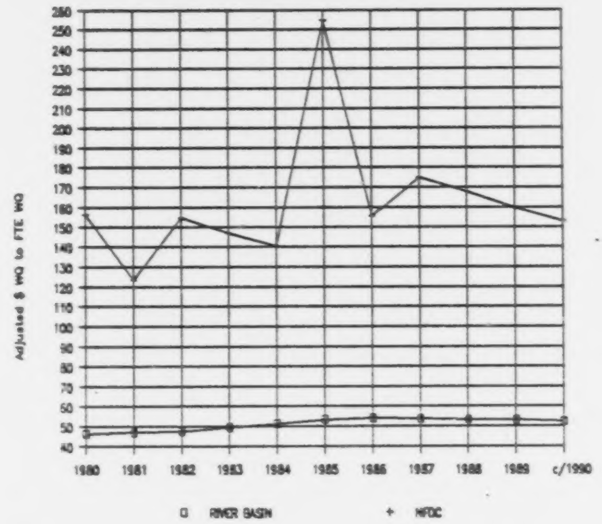
TABLE AND GRAPH 6 OF 8:

TENNESSEE VALLEY AUTHORITY

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for River Basin and NFDC Operations

1980–1990

RIVER BASIN AND NFDC OPERATIONS



(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin Operations NATURAL RESOURCES											
$ WQ	1,858.1	1,035.3	1,475.0	1,286.5	1,743.1	3,896.7	4,155.3	3,493.7	2,928.1	3,450.2	5,503.0
d/FTE WQ	40	22	31	26	34	73	77	65	55	65	105
$ WQ/FTE WQ	46.4	47.1	47.6	49.5	51.3	53.4	54.0	53.7	53.2	53.1	52.4
National Fertilizer Development Center Operations (NFDC) RESEARCH											
$ WQ	642.1	803.0	696.0	1,087.5	1,180.5	1,324.1	1,274.9	1,836.3	1,760.7	1,421.5	1,224.5
d/FTE WQ	4.1	6.5	4.5	7.4	8.4	5.2	8.2	10.5	10.5	8.9	8
$ WQ/FTE WQ	156.6	123.5	154.7	147.0	140.5	254.6	155.5	174.9	167.7	159.7	153.1

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

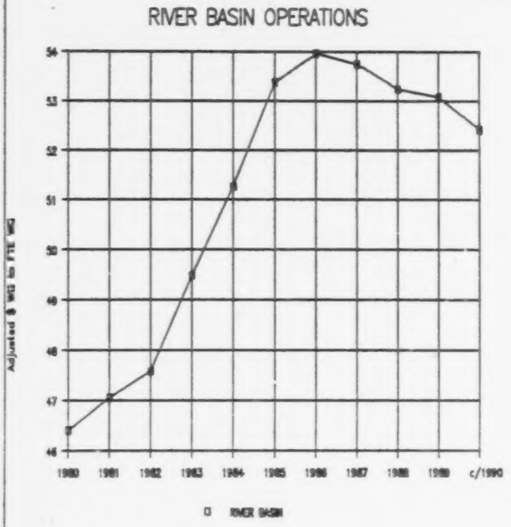
d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

TABLE AND GRAPHS 8 OF 8:

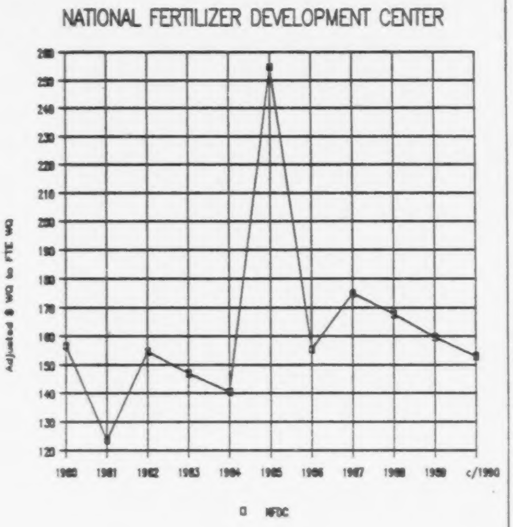
TENNESSEE VALLEY AUTHORITY

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for River Basin and NFDC Operations

1980–1990



RIVER BASIN OPERATIONS



NATIONAL FERTILIZER DEVELOPMENT CENTER

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

FTE = Full-Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin Operations NATURAL RESOURCES											
$ WQ	1,856.1	1,035.3	1,475.0	1,286.5	1,743.1	3,896.7	4,155.3	3,493.7	2,928.1	3,450.2	5,503.0
d/FTE WQ	40	22	31	26	34	73	77	65	55	65	105
$ WQ/FTE WQ	46.4	47.1	47.6	49.5	51.3	53.4	54.0	53.7	53.2	53.1	52.4
National Fertilizer Development Center Operations (NFDC) RESEARCH											
$ WQ	642.1	803.0	696.0	1,087.5	1,180.5	1,324.1	1,274.9	1,836.3	1,760.7	1,421.5	1,224.5
d/FTE WQ	4.1	6.5	4.5	7.4	8.4	5.2	8.2	10.5	10.5	8.9	8
$ WQ/FTE WQ	156.6	123.5	154.7	147.0	140.5	254.6	155.5	174.9	167.7	159.7	153.1

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

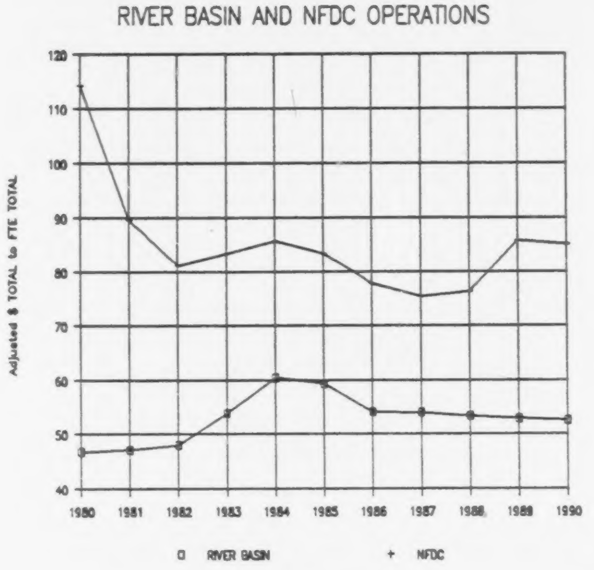
d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

TABLE AND GRAPH 7 OF 8:

TENNESSEE VALLEY AUTHORITY

Relationship of Adjusted Total Funding to Total Personnel for River Basin and NFDC Operations

1980–1990



(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

FTE = Full-Time Equivalent

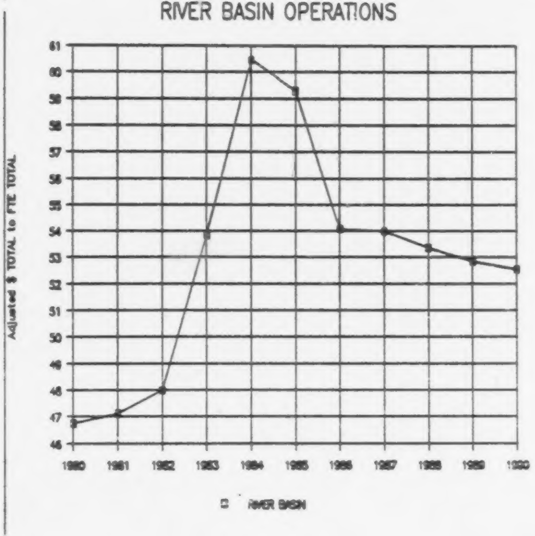
YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
River Basin Operations NATURAL RESOURCES											
$ TOTAL	33,850.3	29,965.7	31,916.0	36,331.7	46,187.8	44,878.0	40,725.1	37,524.1	36,184.3	34,084.8	35,040.5
d/ FTE TOTAL	724	636	665	675	764	757	753	695	678	645	667
$ TOTAL/FTE TOTAL	46.8	47.1	48.0	53.8	60.5	59.3	54.1	54.0	53.4	52.8	52.5
National Fertilizer Development Center Operations (NFDC) RESEARCH											
$ TOTAL	50,973.1	40,455.0	38,925.0	35,734.8	39,037.4	40,179.8	31,305.5	28,542.4	27,168.7	23,816.8	21,465.5
d/ FTE TOTAL	446.4	451.7	479.2	428.4	455.2	481.7	402.3	378.6	356	277.4	252.2
$ TOTAL/FTE TOTAL	114.2	89.6	81.2	83.4	85.8	83.4	77.8	75.4	76.3	85.9	85.1

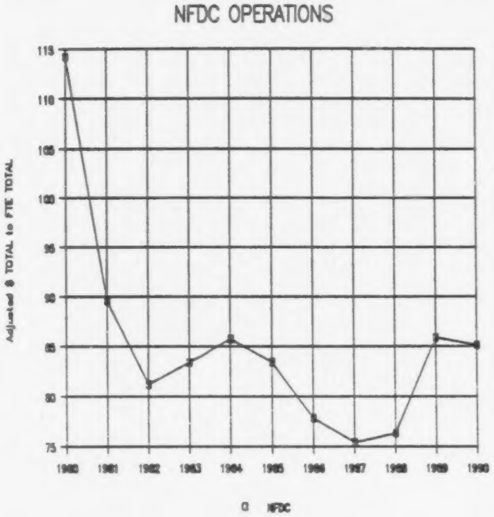
c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

TABLE AND GRAPHS 7 OF 8:

TENNESSEE VALLEY AUTHORITY
Relationship of Adjusted Total Funding to Total Personnel for River Basin and NFDC Operations
1980–1990





(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

FTE = Full–Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
River Basin Operations											
NATURAL RESOURCES											
$ TOTAL	33,850.3	29,965.7	31,916.0	36,331.7	46,187.8	44,878.0	40,725.1	37,524.1	36,184.3	34,084.8	35,040.5
d/ FTE TOTAL	724	636	665	675	764	757	753	695	678	645	667
$ TOTAL/FTE TOTAL	46.8	47.1	48.0	53.8	60.5	59.3	54.1	54.0	53.4	52.8	52.5
National Fertilizer Development Center Operations (NFDC)											
RESEARCH											
$ TOTAL	50,973.1	40,455.0	38,925.0	35,734.8	39,037.4	40,179.8	31,305.5	28,542.4	27,168.7	23,816.8	21,465.5
d/ FTE TOTAL	446.4	451.7	479.2	428.4	455.2	481.7	402.3	378.6	356	277.4	252.2
$ TOTAL/FTE TOTAL	114.2	89.6	81.2	83.4	85.8	83.4	77.8	75.4	76.3	85.9	85.1

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c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

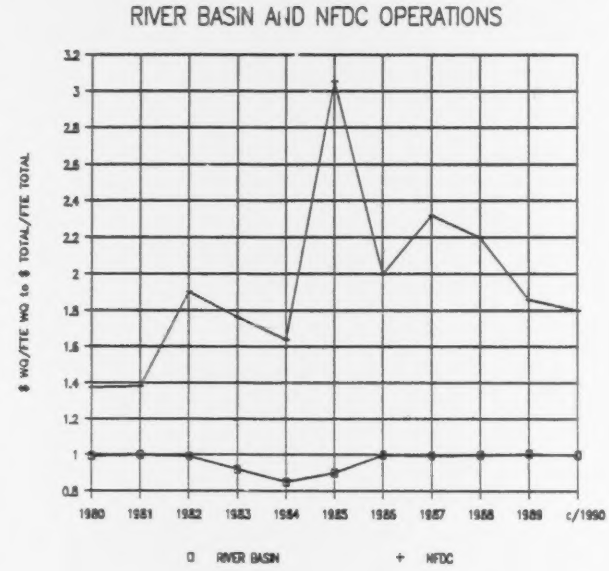
d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

TABLE AND GRAPH 8 OF 8:

TENNESSEE VALLEY AUTHORITY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for River Basin and NFDC Operations

1980–1990



WQ = Water Quality **$ = Appropriated Funds** **FTE = Full-Time Equivalent**

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin **Operations** NATURAL RESOURCES											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	1.0	1.0	0.9	0.8	0.9	1.0	1.0	1.0	1.0	1.0
National Fertilizer **Development Center** **Operations (NFDC)** RESEARCH											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.4	1.4	1.9	1.8	1.6	3.1	2.0	2.3	2.2	1.9	1.8

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

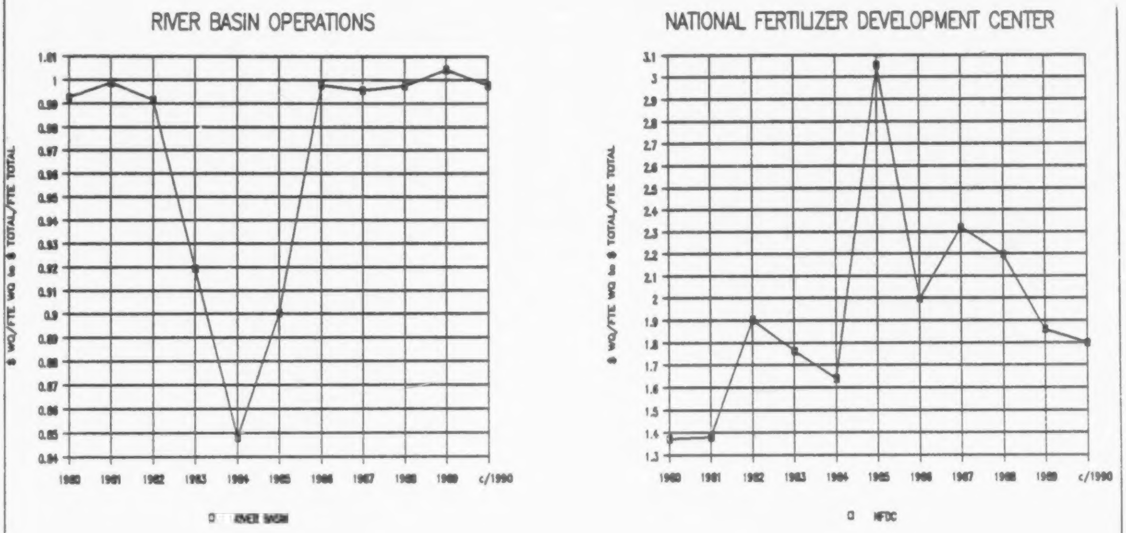
d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

TABLE AND GRAPHS 8 OF 8:

TENNESSEE VALLEY AUTHORITY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for River Basin and NFDC Operations

1980–1990



WQ = Water Quality

$ = Appropriated Funds

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
River Basin **Operations** **NATURAL RESOURCES**											
$ WQ/FTE WQ **$ TOTAL/FTE TOTAL**	1.0	1.0	1.0	0.9	0.8	0.9	1.0	1.0	1.0	1.0	1.0
National Fertilizer Development Center Operations (NFDC) **RESEARCH**											
$ WQ/FTE WQ **$ TOTAL/FTE TOTAL**	1.4	1.4	1.9	1.8	1.6	3.1	2.0	2.3	2.2	1.9	1.8

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

d/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

APPENDIX D: DEPARTMENT OF INTERIOR

As steward of the nation's public lands and natural resources, the Department of Interior (DOI) is charged with protecting and preserving the nation's fish and wildlife; land and water resources; national parks; and historical sites. Created in 1849, the Department of Interior has jurisdiction of more than 500 million acres of Federal land. Furthermore, reclamation of the arid West through irrigation and Indian reservation trusts are the responsibility of DOI.

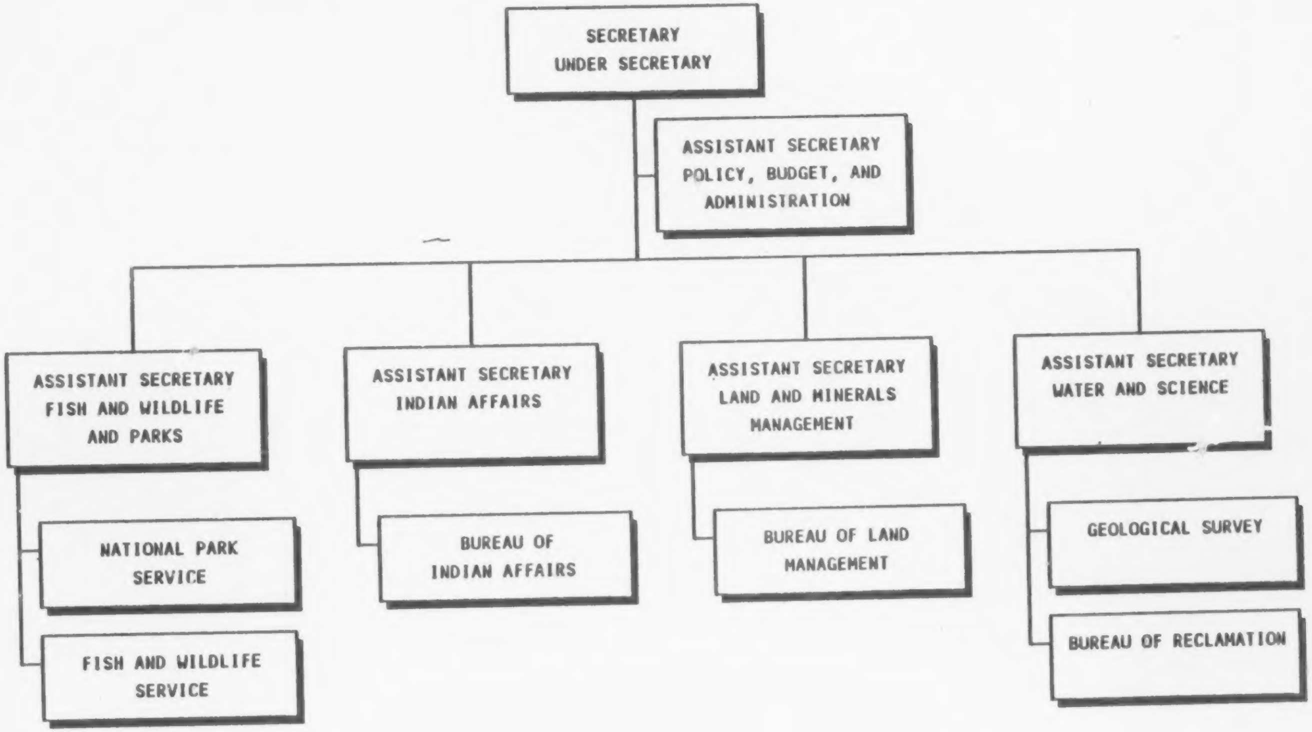
Six of the Interior's ten bureaus or services have water-quality responsibilities. They are the National Park Service, Fish and Wildlife Service, Bureau of Indian Affairs, Bureau of Land Management, the United States Geological Survey, and the Bureau of Reclamation (Figure 4, next page).

Additionally, the Interior's Office of Environmental Project Review is responsible for coordination between the bureaus/services on interagency environmental concerns. As environmental liaison to both EPA and CEQ, the Office of Environmental Project Review oversees Interior's compliance with the National Environmental Policy Act (NEPA).

National Park Service (NPS)

The National Park Service, established by the National Park Organic Act (1916), governs the public use of our national parks, recreation areas, monuments, and historic sites.[35] As part of its mission, NPS--through its Water Resources Division--

Figure 4: UNITED STATES DEPARTMENT OF INTERIOR WATER–QUALITY ORGANIZATIONAL CHART


SECRETARY
UNDER SECRETARY
ASSISTANT SECRETARY POLICY, BUDGET, AND ADMINISTRATION
ASSISTANT SECRETARY FISH AND WILDLIFE AND PARKS
NATIONAL PARK SERVICE
FISH AND WILDLIFE SERVICE
ASSISTANT SECRETARY INDIAN AFFAIRS
BUREAU OF INDIAN AFFAIRS
ASSISTANT SECRETARY LAND AND MINERALS MANAGEMENT
BUREAU OF LAND MANAGEMENT
ASSISTANT SECRETARY WATER AND SCIENCE
GEOLOGICAL SURVEY
BUREAU OF RECLAMATION

preserves and protects National Park Service water resources and water-dependent environments. As a participant of the Federal Interagency Groundwater Protection Committee, NPS supports the Environmental Protection Agency's Groundwater Protection Strategy; furthermore, NPS has proposed--as a benefactor to watershed protection--surface and groundwater monitoring resulting in a comprehensive inventory of the National Park System's watersheds.[29]

Fish and Wildlife Service (FWS)

Originally established as the Bureau of Fisheries (1871), the Fish and Wildlife Service has undergone many reorganizations and transformations over its 110-year history. Yet its mission remains to conserve, protect, and enhance fish, wildlife, and their habitats.[44]

Leaving them to their sister agency (USGS)--the Fish and Wildlife service is not primarily concerned with ground-water issues; however, FWS is involved with the Departmental Irrigation Drainwater Program. FWS's contribution to the program is in biological research at its two research centers: Patuxent Wildlife Research Center, Laurel, Maryland; and the National Fisheries Contaminants Research Center, Columbia, Missouri. Both centers are involved in researching the contaminant, selenium, as it leaches into irrigation waters caused by the flooding of vegetable fields.[6]

Bureau of Indian Affairs (BIA)

Transferred to the Interior from the Department of War (1849), the Bureau of Indian Affairs--acting as federal agent--helps preserve the rights of Native Americans to self-govern and to inherit tribal lands.[44] Within its Land and Water Resources Division, BIA is involved with the Irrigation Drainage Program: seeking a solution to ground-water contamination from long-term irrigation on farmed reservation lands in 13 western States.

Bureau of Land Management (BLM)

In 1946, through merger of the U. S. Grazing Service and the General Land Office, the Bureau of Management was created.[6] Balancing the concepts of multiple use and sustained yield--BLM manages the mineral and land resources of the Nation. BLM's water-quality activities involve watershed protection and management of public lands.

Bureau of Reclamation (BOR)

The Bureau of Reclamation was originally created by the Reclamation Act (1902) to provide a secure, year-round water supply for irrigation to the 17-arid and semiarid States. However, as the U. S. population expanded westward, so did BOR's mission; Reclamation now manages hundreds of reservoirs, dams, and hydroelectric powerplants; and thousands of miles of water tunnels, canals, pipeline, and drains.[44]

As a consequence, BOR employs hundreds of water-quality personnel with expertise in ground water, drainage, and agricultural contamination. These personnel are involved in many water management programs including the Irrigation Drainage Program. In cooperation with USGS, FWS. and BIA, Reclamation implemented a dewatering program of Kesterson National Wildlife Refuge: the site impacted by the selenium-contaminated agricultural drainwater.

Additionally, Reclamation developed water management and conservation programs to provide proper timing and application of chemigated waters--to minimize ground-water contamination--of agricultural land. Furthermore, Reclamation's Colorado River Basin Salinity Control Program (in cooperation with the Soil Conservation Service) is making significant inroads to reducing the salt load to the Colorado River--by lining agricultural drainage canals to prevent salt pick up and by implementing on-farm improvements to reduce deep percolation of agricultural chemicals to ground water.

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The Bureau of Reclamation has a well-established water-research program, resulting in new advances for irrigation. Reclamation's new developments that look promising are a chemical water treatment for selenium removal, and a low-cost, long-lasting geomembrane/concrete lining system to prevent water seepage in drainage canals.[7]

United States Geological Survey (USGS)

In 1879, the United States Geological Survey was established to identify and classify the land, water, mineral, and energy resources of the Nation.[44] Two of its three divisions are directly involved with National water-resource objectives.

Geologic Division (GD)

Involved with geologic mapping or process research, Geologic Divisions's contribution to resolving ground-water contamination is to evaluate the physical flowpathways of ground water.[51]

Water Resources Division (WRD)

Providing hydrologic data necessary for managing the Nation's water resources is the overall mission of the Water Resources Division, USGS. In cooperation with State and local governments, WRD monitors National surface and ground water at selected sampling sites; and conducts research in hydrology, hydraulics, and related fields.

Additionally, Water Resources operates the following programs:

1. Toxic Waste--Ground Water Contamination - A program developed to provide other Federal agencies, State and local governments with earth-science information for the safe clean up and management of hazardous waste.[65]
2. Water-Data - The water data collected at stream and well sites provides the information necessary for environmental impact assessments and hydrologic appraisals.[66]
3. National Water-Use Information - A cooperative program designed to collect, store, analyze, and disseminate water-use data to federal, state, and local agencies; and private organizations.
4. National Water-Quality Assessment Program - A program designed to assess the Nation's water-quality; identify the factors determining its quality, and possible trends.

USGS TABLES:

The interpretation of tables 1-5 are left to the reader. Full-time equivalents were not in use prior to 1982; therefore, personnel-resource totals for 1980 and 1981 are estimates (and fluctuations in graphic trends in those years may be attributed to these estimates). Table 8 displays a ratio of less than, equal to, or greater than one. A ratio of one represents a fair allocation of appropriated funds to personnel for water-quality objectives when compared to overall budgetary allocations.

USGS MID-CONTINENT HERBICIDE INITIATIVE

- only herbicide

Founded with USGS by Dr. Stephen Ragone, Water Resources--the Initiative's objective is to seek a resolution to the herbicide contamination problems (primarily atrazine) occurring in the corn belt: the mid-continent region of the United States.[8] Participants in the Mid-Continent Herbicide Initiative include State and Federal natural resources, extension, and soil conservation personnel.

Three major categories are identified as needing further research: 1) macro-pore transport; 2) biological and chemical transformation; and 3) sorption storage. A team approach was adopted by the Initiative participants; the following teams were formed:[8]

1. Topical Strategy Team - Responsible for planning work with the above topical categories.
2. GIS Design Strategy Team - Responsible for defining sources and availability of digital data on the mid-continent region. (Note: GIS is the acronym for Geographic Information System, a database constructed from geographic information.)
3. Model Verification Team - Responsible for developing water models for the Region based on GIS data.

As a result, a Technical Coordinating Committee and an Interagency Committee will be formed not only to coordinate research efforts but also to develop Federal agreements between the participating agencies.

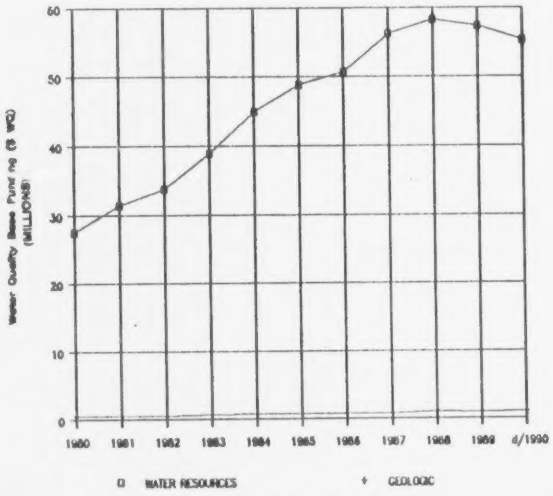
TABLE AND GRAPH 1 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Water Quality Base Funding for Water Resources and Geologic Divisions

1980–1990

WATER RESOURCES AND GEOLOGIC DIVISIONS



(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
Water Resources Division											
c $ WQ	27,500.0	31,400.0	33,800.0	38,900.0	45,000.0	48,900.0	50,700.0	56,300.0	58,300.0	57,400.0	55,400.0
$ TOTAL	112,948.0	118,962.0	109,604.0	116,039.0	129,441.0	132,844.0	134,802.0	141,227.0	149,147.0	145,321.0	138,451.0
Geologic Division											
b $ WQ	500.0	500.0	550.0	700.0	750.0	800.0	800.0	822.0	997.0	959.0	1,023.0
$ TOTAL	142,497.0	158,276.0	157,545.0	159,816.0	164,354.0	169,762.0	165,574.0	169,023.0	177,161.0	178,199.0	171,426.0

b/ Geologic Division's $ WQ:
This level of project effort consisted of geologic mapping or process research that provides a physical or conceptual basis for evaluating the flow pathways of ground water.
Source: Dr. Mitchell W. Reynolds, Acting Chief, Office of Regional Geology, USGS.
c/ Source: Mr. Paul R. Beachemin, Program Officer, Water Resources Division, USGS.
d/ The $ WQ, and $ TOTALS are from the President's FY 1990 Budget Request.

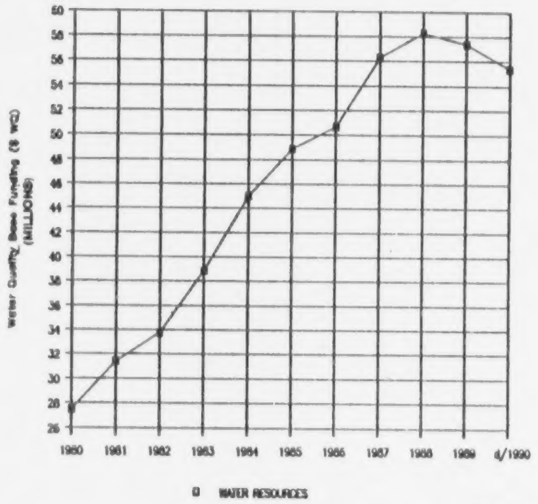
TABLE AND GRAPHS 1 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Water Quality Base Funding for Water Resources and Geologic Divisions

1980–1990

WATER RESOURCES DIVISION



GEOLOGIC DIVISION

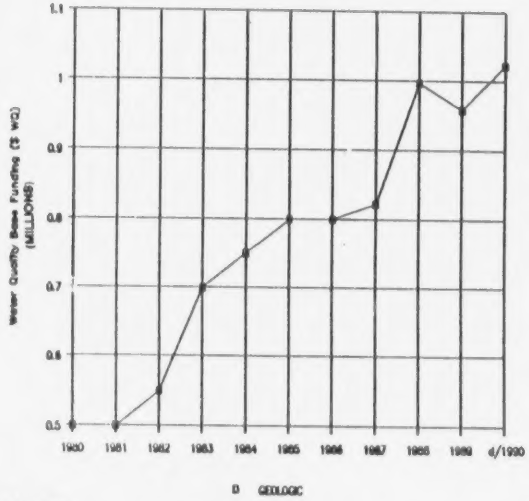


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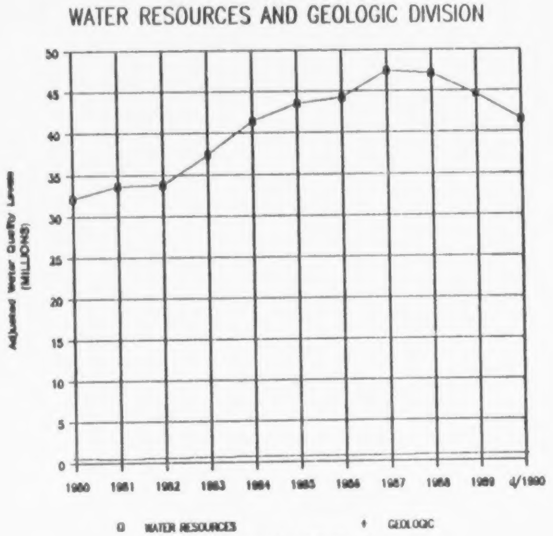
TABLE AND GRAPH 2 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Adjusted Water Quality Funding Levels for Water Resources and Geologic Divisions

1980-1990



(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
1982 GNP Deflator Index Values:	0.855	0.934	1	1.04	1.086	1.123	1.146	1.185	1.237	1.286	1.332
Water Resources Division											
c $ WQ	32,163.7	33,618.8	33,800.0	37,403.8	41,436.5	43,544.1	44,240.8	47,510.5	47,130.2	44,634.5	41,591.6
$ TOTAL	132,102.9	127,368.3	109,604.0	111,576.0	119,190.6	118,293.9	117,628.3	119,178.9	120,571.5	113,002.3	103,942.2
Geologic Division											
b $ WQ	584.8	535.3	550.0	673.1	690.6	712.4	698.1	693.7	806.0	745.7	768.0
$ TOTAL	166,663.2	169,460.4	157,545.0	153,669.2	151,338.9	151,168.3	144,479.9	142,635.4	143,218.3	138,568.4	128,698.2

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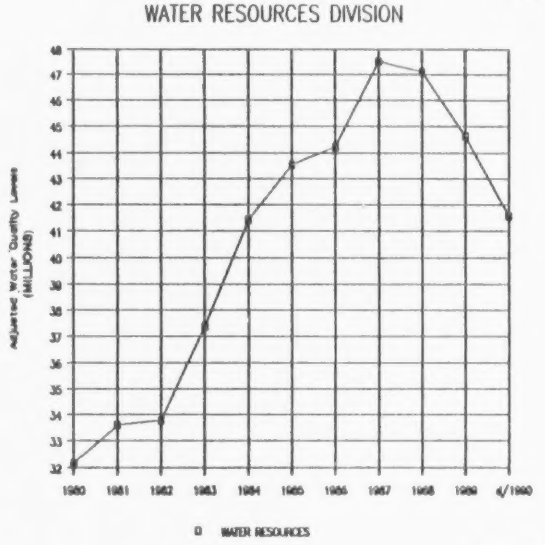

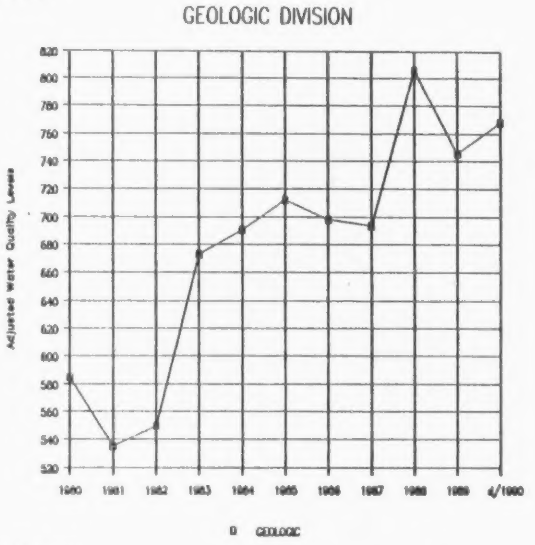

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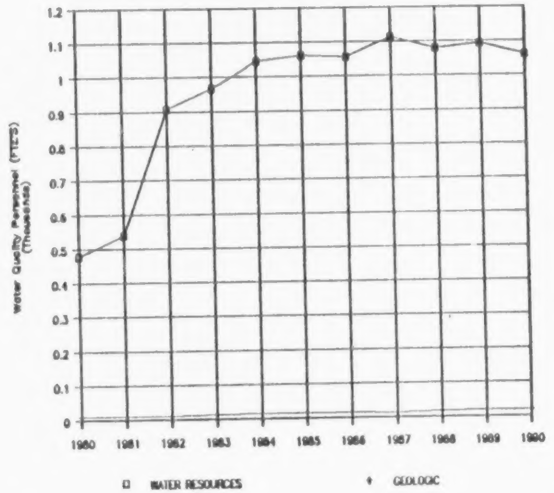
TABLE AND GRAPH 3 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Water Quality Personnel Resources for Water Resources and Geologic Divisions

1980-1990

WATER RESOURCES AND GEOLOGIC DIVISION



WQ = Water Quality

FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Water Resources Division											
a FTE WQ	477	538	909	967	1,046	1,062	1,057	1,114	1,080	1,094	1,061
a FTE TOTAL	2,285	2,321	2,925	2,911	2,893	2,881	2,914	2,914	2,852	2,876	2,812
Geologic Division											
a FTE WQ	10	10	11	14	15	16	16	14	17	19	19
a FTE TOTAL	2,485	2,553	2,979	2,767	2,620	2,697	2,641	2,474	2,464	2,483	2,467

a/ FTE's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982.

Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

TABLE AND GRAPHS 3 OF 8:

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1980–1990

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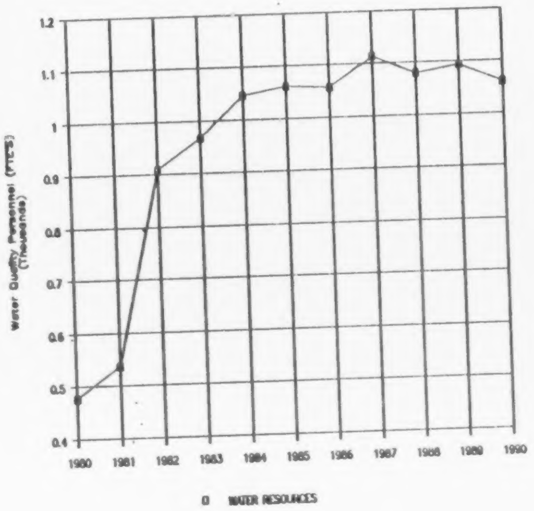

GEOLOGIC DIVISION

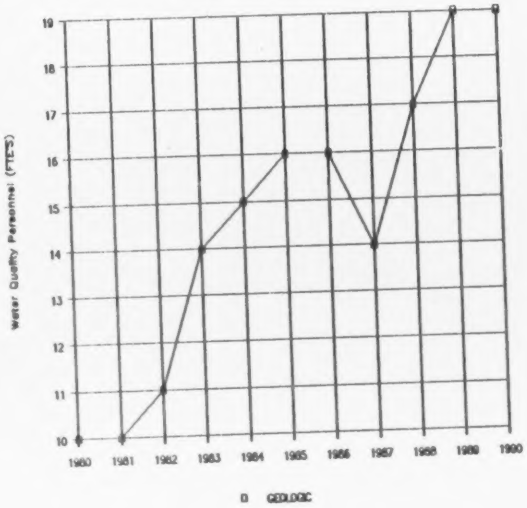

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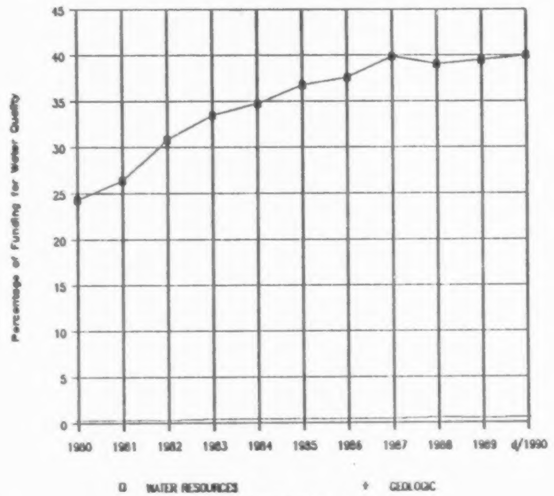
TABLE AND GRAPH 4 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Percentage of Adjusted Funding Directed to Water Quality for Water Resources and Geologic Divisions

1980–1990

WATER RESOURCES AND GEOLOGIC DIVISION



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YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
Water Resources Division											
c/ $ WQ	32,163.7	33,618.8	33,800.0	37,403.8	41,436.5	43,544.1	44,240.8	47,510.5	47,130.2	44,634.5	41,591.6
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$ WQ/$ TOTAL (%)	24.3	26.4	30.8	33.5	34.8	36.8	37.6	39.9	39.1	39.5	40.0
Geologic Division											
b/ $ WQ	584.8	535.3	550.0	673.1	690.6	712.4	698.1	693.7	806.0	745.7	768.0
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$ WQ/$ TOTAL (%)	0.4	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.6	0.5	0.6

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1980–1990

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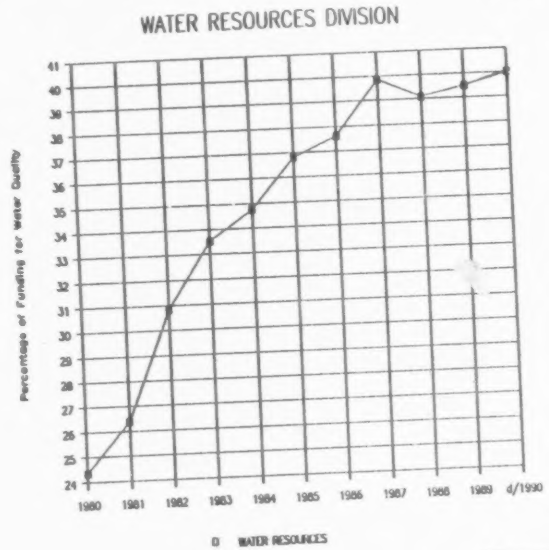

GEOLOGIC DIVISION

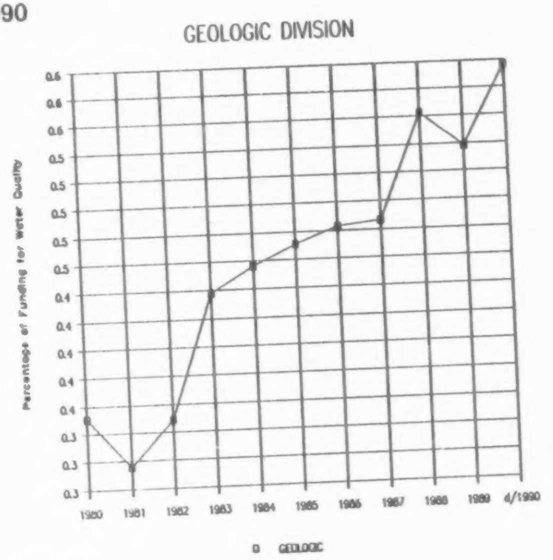

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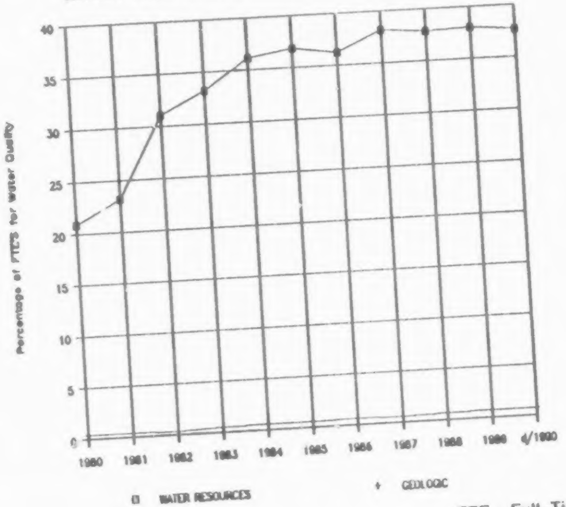
TABLE AND GRAPH 5 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Percentage of Total Personnel Assigned to Water Quality for Water Resources and Geologic Divisions

1980-1990

WATER RESOURCES AND GEOLOGIC DIVISION



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FTE WQ/FTE TOTAL (%)	20.9	23.2	31.1	33.2	36.2	36.9	36.3	38.2	37.9	38.0	37.7
Geologic Division											
a/ FTE WQ	10	10	11	14	15	16	16	14	17	19	19
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1980–1990

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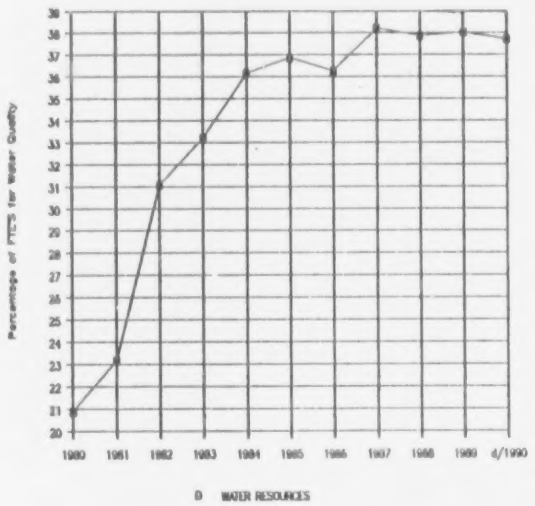

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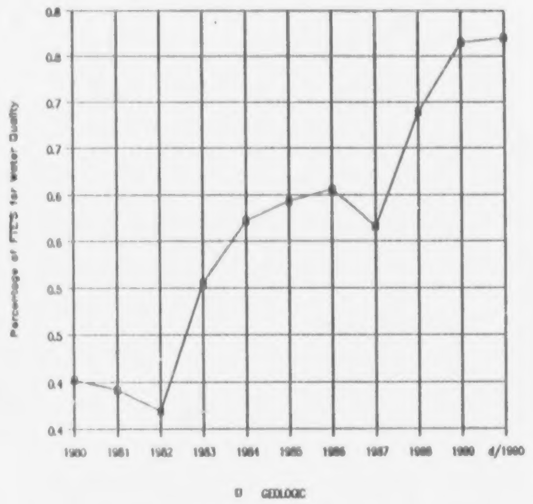
GEOLOGIC DIVISION



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Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

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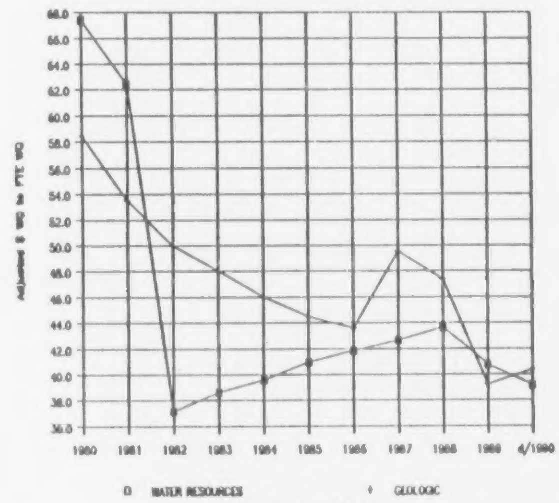
TABLE AND GRAPH 8 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Water Resources and Geologic Divisions

1980-1990

WATER RESOURCES AND GEOLOGIC DIVISIONS



(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
Water Resources Division												
c/	$ WQ	32,163.7	33,618.8	33,800.0	37,403.8	41,436.5	43,544.1	44,240.8	47,510.5	47,130.2	44,634.5	41,591.6
a/	FTE WQ	477	538	909	967	1,046	1,062	1,057	1,114	1,080	1,094	1,061
	$ WQ/FTE WQ	67.4	62.5	37.2	38.7	39.6	41.0	41.9	42.6	43.6	40.8	39.2
Geologic Division												
b/	$ WQ	584.6	535.3	550.0	673.1	690.6	712.4	698.1	693.7	806.0	745.7	768.0
a/	FTE WQ	10	10	11	14	15	16	16	14	17	19	19
	$ WQ/FTE WQ	58.5	53.5	50.0	48.1	46.0	44.5	43.6	49.5	47.4	39.2	40.4

a/ FTE 's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982.
Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

b/ Geologic Division's $ WQ:
This level of project effort consisted of geologic mapping or process research that provides a physical or conceptual basis for evaluating the flow pathways of ground water.
Source: Dr. Mitchell W. Reynolds, Acting Chief, Office of Regional Geology, USGS.

c/ Source: Mr. Paul R. Beachemin, Program Officer, Water Resources Division, USGS.

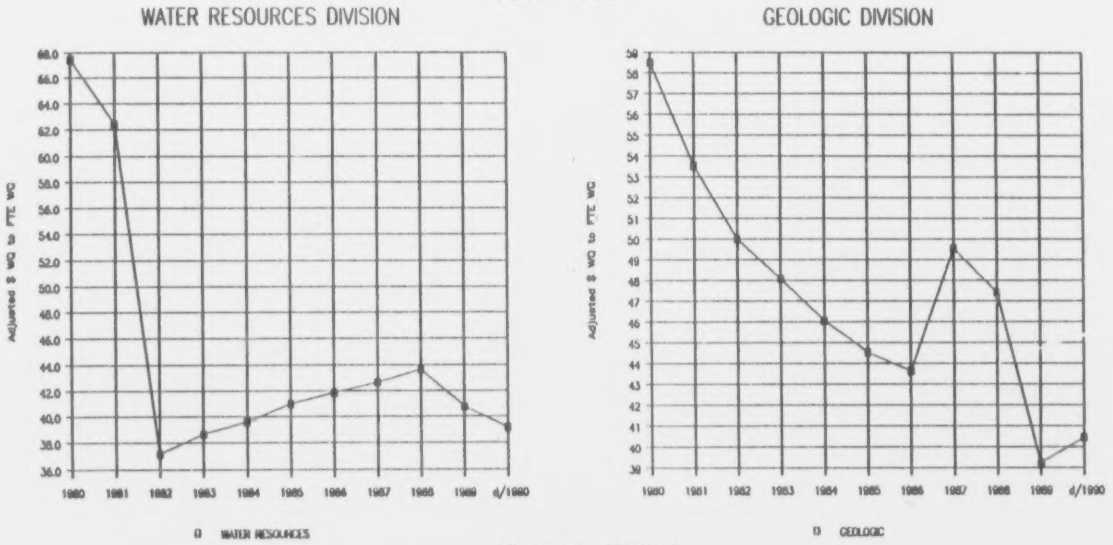
d/ The $ WQ, and $ TOTALS are from the President's FY 1990 Budget Request.

TABLE AND GRAPHS 6 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Water Resources and Geologic Divisions

1980–1990


WATER RESOURCES DIVISION

GEOLOGIC DIVISION

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
Water Resources												
Division												
c/	**$ WQ**	32,163.7	33,618.8	33,800.0	37,403.8	41,436.5	43,544.1	44,240.8	47,510.5	47,130.2	44,634.5	41,591.6
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	$ WQ/FTE WQ	67.4	62.5	37.2	38.7	39.6	41.0	41.9	42.6	43.6	40.8	39.2
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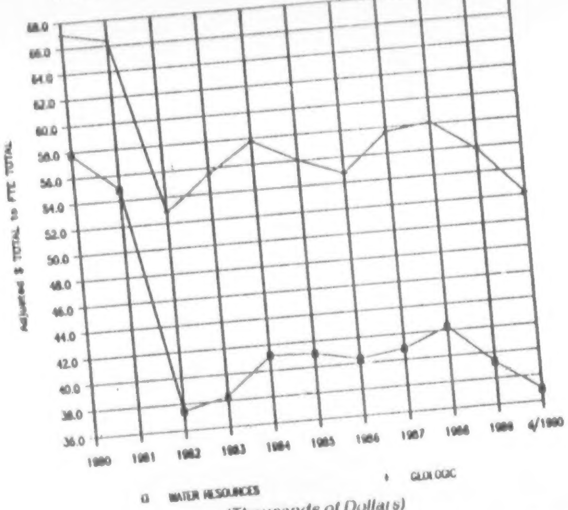
TABLE AND GRAPH 7 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Relationship of Adjusted Total Funding to Total Personnel for Water Resources and Geologic Divisions

1980-1990

WATER RESOURCES AND GEOLOGIC DIVISIONS



(Thousands of Dollars)

WQ = Water Quality　$ = Appropriated Funds　FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
Water Resources Division											
$ TOTAL	132,102.9	127,366.3	109,604.0	111,576.0	119,190.6	118,293.9	117,628.3	119,178.9	120,571.5	113,002.3	103,942.2
a/ FTE TOTAL	2,285	2,321	2,925	2,911	2,893	2,881	2,914	2,914	2,852	2,876	2,812
$ TOTAL/FTE TOTAL	57.8	54.9	37.5	38.3	41.2	41.1	40.4	40.9	42.3	39.3	37.0
Geologic Division											
$ TOTAL	166,663.2	169,460.4	157,545.0	153,669.2	151,338.9	151,168.3	144,479.9	142,635.4	143,218.3	138,568.4	128,698.2
a/ FTE TOTAL	2,485	2,553	2,979	2,767	2,620	2,697	2,641	2,474	2,484	2,483	2,467
$ TOTAL/FTE TOTAL	67.1	66.4	52.9	55.5	57.8	56.1	54.7	57.7	58.1	55.8	52.2

a/ FTE 's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982.
Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

d/ The $ WQ, and $ TOTALS are from the President's FY 1990 Budget Request.

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TABLE AND GRAPHS 7 OF 8:

UNITED STATES GEOLOGICAL SURVEY

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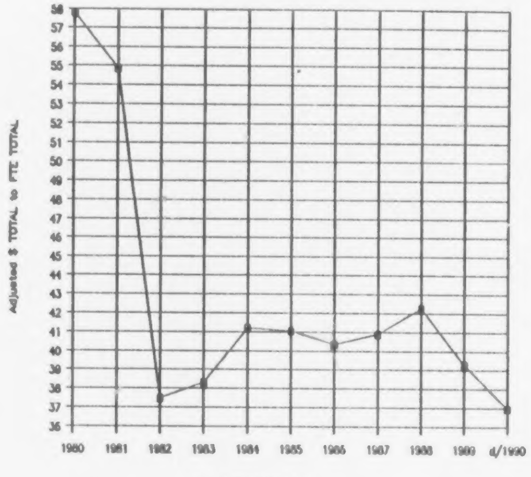
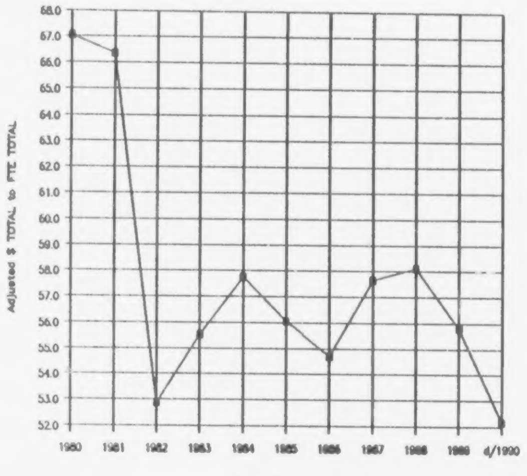
1980–1990

WATER RESOURCES DIVISION



GEOLOGIC DIVISION



(Thousands of Dollars)

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	YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	d/1990
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Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.
d/ The $ WQ, and $ TOTAL$ are from the President's FY 1990 Budget Request.

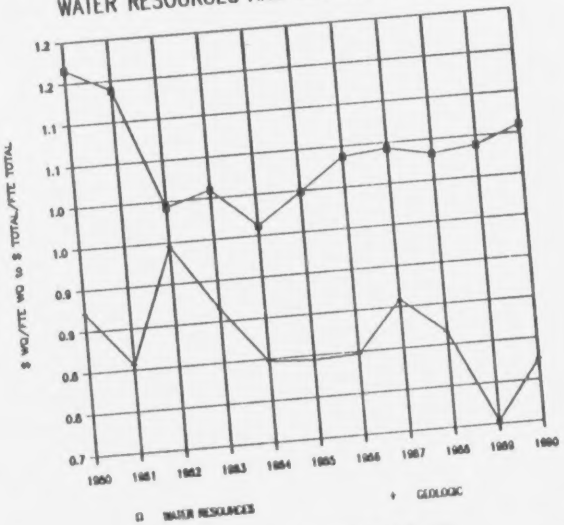
TABLE AND GRAPH 8 OF 8:

UNITED STATES GEOLOGICAL SURVEY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Water Resources and Geologic Divisions

1980–1990

WATER RESOURCES AND GEOLOGIC DIVISION



WQ = Water Quality

$ = Appropriated Funds

FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Water Resources Division $ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
Geologic Division $ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.9	0.8	0.9	0.9	0.8	0.8	0.8	0.9	0.8	0.7	0.8

a/ FTE's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982.
Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

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Source: Dr. Mitchell W. Reynolds, Acting Chief, Office of Regional Geology, USGS.

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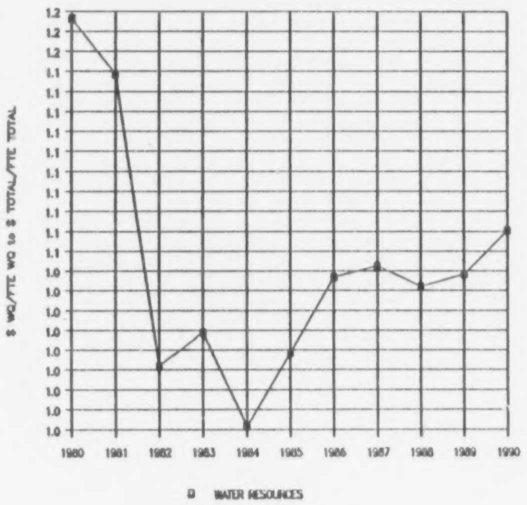
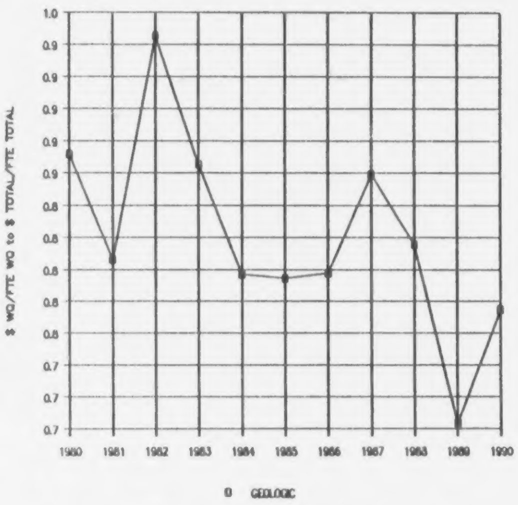


GEOLOGIC DIVISION



WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Water Resources Division											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.2	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1
Geologic Division											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.9	0.8	0.9	0.9	0.8	0.8	0.8	0.9	0.8	0.7	0.8

a/ FTE 's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982.
Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

b/ Geologic Division's $ WQ:
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Source: Dr. Mitchell W. Reynolds, Acting Chief, Office of Regional Geology, USGS.

c/ Source: Mr. Paul R. Beachemin, Program Officer, Water Resources Division, USGS.

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APPENDIX E: UNITED STATES DEPARTMENT OF AGRICULTURE

Established in 1862, the United States Department of Agriculture's (USDA) basic objective is to develop and to expand markets--both at home and abroad--for U.S. agricultural products while maintaining successful environmental-conservation programs for our nation's natural resources. Additionally, the USDA implements programs to improve farm income and to aid the development of rural America.[44] Of the USDA's thirty-six agencies, the following eleven are involved in water-quality activities (Figure 5):

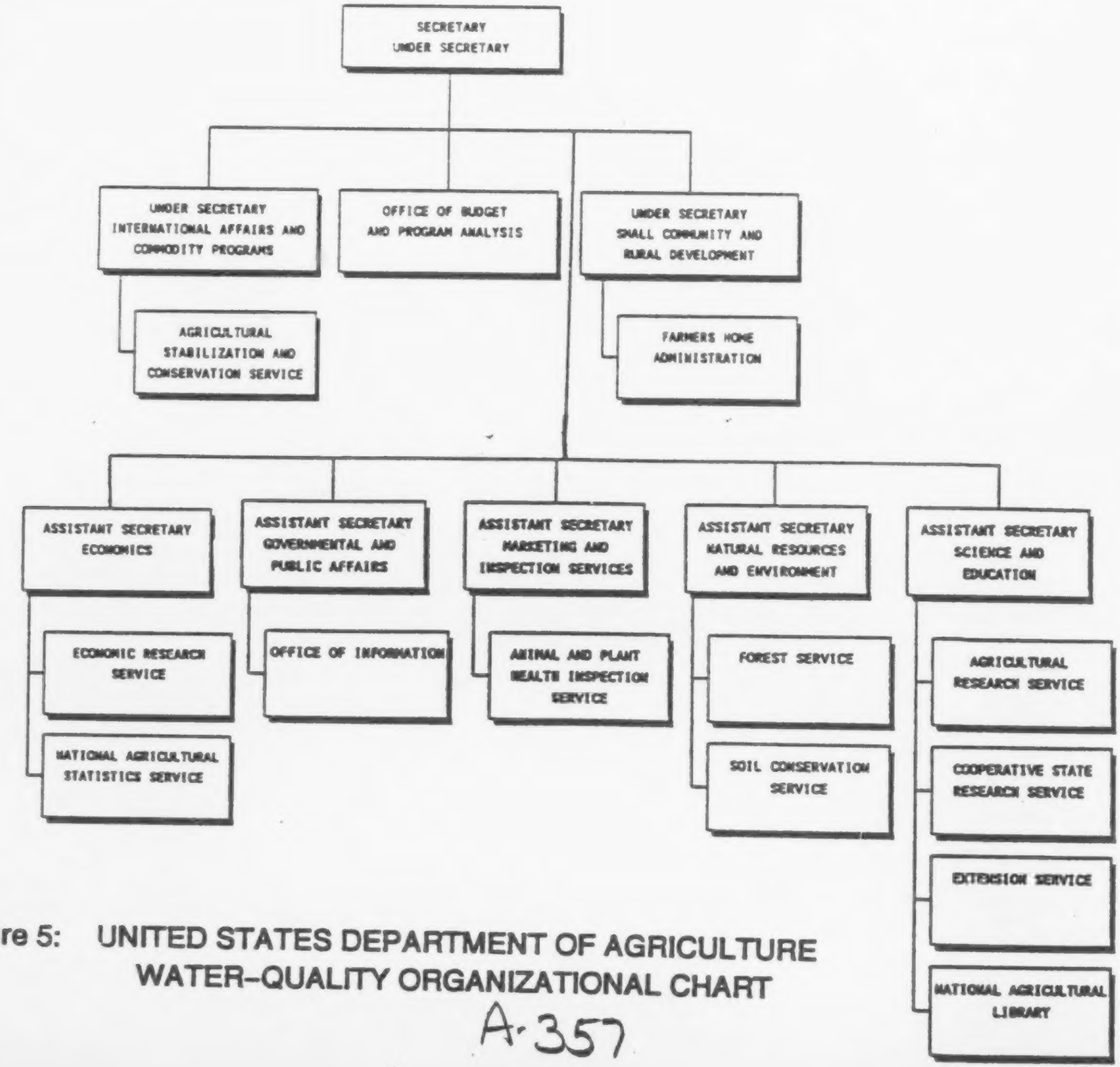
SECRETARY
UNDER SECRETARY
UNDER SECRETARY INTERNATIONAL AFFAIRS AND COMMODITY PROGRAMS
OFFICE OF BUDGET AND PROGRAM ANALYSIS
UNDER SECRETARY SMALL COMMUNITY AND RURAL DEVELOPMENT
AGRICULTURAL STABILIZATION AND CONSERVATION SERVICE
FARMERS HOME ADMINISTRATION
ASSISTANT SECRETARY ECONOMICS
ASSISTANT SECRETARY GOVERNMENTAL AND PUBLIC AFFAIRS
ASSISTANT SECRETARY MARKETING AND INSPECTION SERVICES
ASSISTANT SECRETARY NATURAL RESOURCES AND ENVIRONMENT
ASSISTANT SECRETARY SCIENCE AND EDUCATION
ECONOMIC RESEARCH SERVICE
NATIONAL AGRICULTURAL STATISTICS SERVICE
OFFICE OF INFORMATION
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
FOREST SERVICE
SOIL CONSERVATION SERVICE
AGRICULTURAL RESEARCH SERVICE
COOPERATIVE STATE RESEARCH SERVICE
EXTENSION SERVICE
NATIONAL AGRICULTURAL LIBRARY

Figure 5: UNITED STATES DEPARTMENT OF AGRICULTURE WATER-QUALITY ORGANIZATIONAL CHART

USDA Water Quality Program Plan

In response to the President's Water Quality Initiative, the USDA has developed a Water Quality Program Plan. The Plan's objectives are to determine how present agricultural practices impact ground and surface water; and for those practices having negative impacts, to develop economically-sound alternative practices. USDA's strategy involves 1) education and technical assistance 2) research and development and 3) database development (establishing a Geographic Information System). USDA plans to integrate these strategies into established conservation programs such as Integrated Pest Management (IPM), Low Input Sustainable Agriculture (LISA), and the National Agricultural Pesticide Impact Assessment Program (NAPIAP).[63]

USDA Water-Quality Tables:

In general, **water-quality program activities** are not earmarked budgetary items (an exception, the Extension Service); hence, the agencies subjectively identified the water-quality elements within their ongoing programs. For those agencies whose missions are more closely tied to ground water, the decision was more clearcut. However for others, such as the Forest Service and Animal/Plant Health Inspection Service--whose missions are not so closely aligned--the task was more difficult.

Another discrepancy in USDA figures is found in the $ Total and FTE Total figures for Tables 1, 2, 3, 4, and 5. Some USDA budgetary officers interpret their agency's budgetary totals from the USDA Special Budgetary Tables; yet, others interpret their agency's budgetary totals from the President's Budget Appendix. For an individual agency, the figures represented in these two documents differ significantly.

Science and Education

Agricultural Research Service (ARS)

The Agricultural Research Service's mission is to perform the basic and applied research necessary to promote fundamental improvements in agriculture.

> ARS Tables. Though water-quality funding and personnel resources have increased for the decade (Table 1 and 3), a smaller portion of ARS's overall budget has been applied to water-quality activities (Table 8).

Cooperative State Research Service (CSRS)

The Cooperative State Research Service oversees grant funds supplied by Congress to the state agricultural experiment stations, land-grant universities, and other eligible institutions. In a cooperative effort with the states, CSRS administers Hatch Act and competitive grants programs to promote basic research in agriculture and related sciences.

USDA's Current Research Information System (CRIS) has 839 water-quality research grants currently active within the States and U. S. territories (Figure 6). Additionally CSRS funds support extramural research, approximately 90 scientist-years, at the colleges and universities. Moreover, colleges and universities receive non-Federal funding for water quality research; based on the most recent data available, colleges and universities received $73 million (414 scientist-years) in 1986

Figure 6:

USDA CURRENT RESEARCH INFORMATION SYSTEM*
*CRIS
WATER-QUALITY FILE
STATE AGRICULTURAL EXTENSION SERVICE
1988 ACTIVE

STATES & TERRITORIES	*SOIL SURVEY*	*WATER/CHEMICAL USAGE IN CROPPING SYSTEMS*	*WATER-QUALITY MONITORING & WATERSHED MANAGEMENT*	*WASTE WATER MANAGEMENT*	*MISCELLANEOUS*	*TOTAL*
ALABAMA	4	2	3	1		10
ALASKA			1		1	2
ARKANSAS	2	7	6	6	1	22
ARIZONA	15	29	10	3		57
CALIFORNIA	11	25	17	11	1	65
COLORADO	4	15	12	1	3	35
CONNECTICUT	1	1	2	5	1	10
DIST. OF COLUMBIA	1					1
DELAWARE	1	4	5	6		16
FLORIDA	3	18	5	9		35
GEORGIA	3	6	2	5		16
HAWAII	2	6	1	2	2	13
IDAHO	1	3	4	1	1	10
ILLINOIS		5	7		2	14
INDIANA	4	4	5		1	14
IOWA	5	2	4	2	1	14
KANSAS	1	10	8		3	22
KENTUCKY	6	3	2	1		12
LOUISIANA		3	4	1		8
MAINE			2	2		4
MARYLAND	2	1	3	3		9
MASSACHUSETTS			2	2		4
MICHIGAN	2	4	8	2		16
MINNESOTA	2	4	6	2	1	15
MISSISSIPPI	2	3	2	2		9
MISSOURI	4	1	5	1	1	12
MONTANA	1	6	1		1	9
NORTH CAROLINA	4	5	4	5	1	19
NORTH DAKOTA	7	2	5		2	16
NEBRASKA	6	13	12			31
NEVADA	1	2	8	1		12
NEW HAMPSHIRE	1		3	3		7
NEW JERSEY	1	1	4	5		11
NEW MEXICO	1	9	4	2	2	18
NEW YORK	7	9	20	4	1	41
OHIO	3	3	2	3	1	12
OKLAHOMA	1	2	10		1	14
OREGON	1	15	5	2		23
PENNSYLVANIA		2	6	5	2	15
PUERTO RICO		1				1
RHODE ISLAND		1	3	4		8
SOUTH CAROLINA	4	3	3	2		12
SOUTH DAKOTA	2	3	3			8
TENNESSEE	3	2	2		1	8
TEXAS	2	27	23	5	1	58
UTAH		5	9			14
VERMONT			2			2
VIRGINIA	2	2	6	1		11
VIRGIN ISLANDS		3			1	4
WASHINGTON		3	9			12
WEST VIRGINIA	2		3	2	1	8
WISCONSIN		2	10			12
WYOMING		1	7			8
TOTAL:	125	278	290	112	34	839

SOURCE: CSRS, USDA

and $86 million (475 scientist-years) in 1987.[13]

CSRS Tables. Though water-quality funding has increased for the decade (Table 1), a smaller portion of CSRS's overall budget has been applied to water-quality activities (Table 4). In the water-quality tables, CSRS has two Federal FTE's and because the nature of its mission, no state FTE's are represented. Therefore, all graphs depicting comparisons between funding and personnel resources (Tables 6, 7, and 8) are skewed, and no comparisons between funding and personnel resources can be made.

Extension Service (ES)

Created by the Smith-Lever Act of 1914, the Extension Service is the federal partner in the Cooperative Extension System.[12] ES is the educational agency of the USDA providing programs to transfer federal- and state-agricultural-research information to the communities of the Nation. The Extension Service administers core program funding consisting of the Smith-Lever, 1890's Tuskegee, and D. C. extension programs (Figures 7 and 8). Additionally, ES oversees 17 earmarked programs of which water-quality is one. One key point should be noted--for the decade, the number and funding of both core and earmarked programs have increased; yet, the federal ceiling on the number of full-time equivalents has decreased.

ES Tables. The three FTE's represented for fiscal years 1986-1990 are federal staff years; prior to 1986, the Federal FTE's cannot be identified; however, at the State level there are 490 FTE's for water quality.

National Agricultural Library (NAL)

Located in Beltsville, Maryland, the National Agricultural Library is the largest agricultural library in the United

Figure 7:

Core and Earmarked Programs, and FTE's Within States

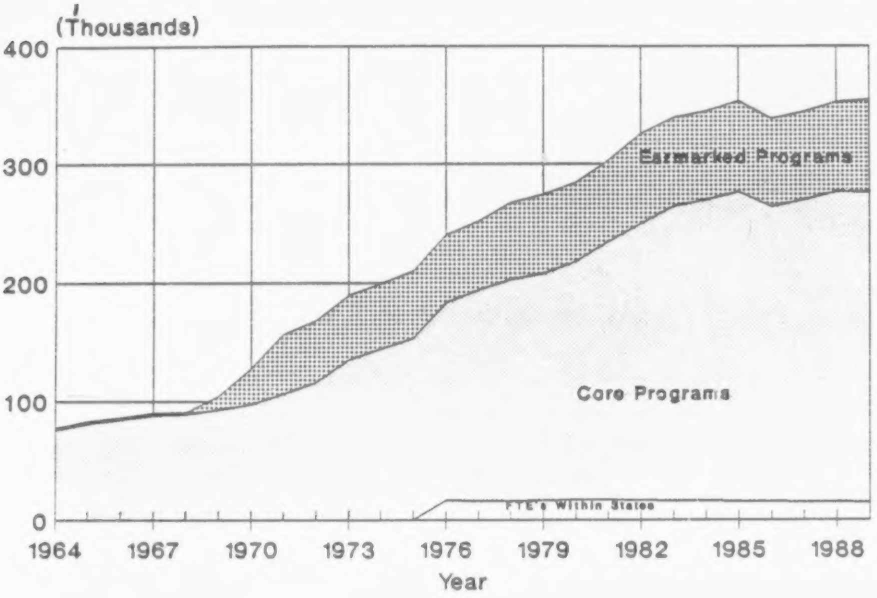

Figure 8:

EXTENSION SERVICE – FTE'S WITHIN STATES
1976–1979

YEAR	TOTAL PROFESSIONALS
1976	16,732
1977	16,279
1978	16,480
1979	16,873
1980	17,015
1981	17,009
1982	16,733
1983	16,314
1984	16,049
1985	16,002
1986	15,886
1987	15,378
1988	15,270
1989	15,008

States.[19] NAL has extensive information within its AGRICOLA database (Agricultural Online Access) on both surface- and ground-water protection and contamination. To make that information and any newly entered information available, NAL has established the Water Information Network (WIN) on its electronic bulletin board.

> **NAL Tables**. NAL has never received water-quality funding or personnel resources prior to the President's 1990 Budget Request. NAL has requested funding to implement a water-quality information center.[20]

National Resources and the Environment

Forest Service (FS)

The Forest Service manages 191 million acres of public land collectively known as the National Forest System.[50] As a part of its ongoing mission, FS is continually researching new technologies to use forest and rangeland resources more productively with the least damage to the environment. Hence, water-quality is one of its national research priorities.[49]

> FS Tables. The Forest Service mission indirectly involves it with ground-water protection. Hence, FS had the difficult task of subjectively identifying which elements of ongoing programs provided water-quality benefits, and therefore, could be declared water-quality programs.

Soil Conservation Service (SCS)

Directly linked with ground-water protection, the Soil Conservation Service is charged with developing and implementing a National soil and water conservation program.[54] In cooperation with other Federal agencies, and State and local governments, SCS provides the technical expertise necessary for natural-resource conservation and development planning.

SCS Tables. Over the last decade, the amount of funding and personnel resources delegated to water-quality has increased substantially (Tables 4 and 5). In 1989 and 1990, water-quality receives an equitable share of SCS's overall budgetary allocations (Table 8).

Marketing and Inspection Service

Animal and Plant Health Inspection Service (APHIS)

The Animal and Plant Health Inspection Service was established to improve and protect animal and plant health for the benefit of mankind and the environment.[2] In cooperation with the States, APHIS imposes regulatory controls using quarantines, treatment, and pest-eradication programs.

APHIS Tables. Prior to 1987, APHIS had no water-quality initiative identified in its ongoing programs. For 1987 and thereafter, APHIS has identified ongoing programs that contribute to the reduction of pesticide use; these programs do not represent direct water-quality projects.

Economics

Economic Research Service (ERS)

Created in 1961, the Economic Research Service's primary mission is to produce situation/outlook and economic/statistical indicators to aid Congress in developing sound rural policy.[44] As a consequence, ERS (within its Resources and Technology Division) is researching "the economic dimensions of water-quality issues related to agriculture."[31]

ERS Tables. ERS $ WQ and FTE WQ figures are unavailable prior to 1984. As the water-quality issue became paramount, ERS's funding and personnel resources have grown significantly (Table 4, 5, and 8).

National Agricultural Statistics Service (NASS)

As USDA's statistics agency, the National Agricultural Statistics Service performs analyses of various elements such as production, supply, and price that have an impact on the U. S. agricultural economy. NASS's appropriations provide funding for two programs: Crop and Livestock Estimates Program, and Statistical Research Program.[9]

NASS Tables. NASS has never received direct funding for water-quality programs; however, NASS receives water quality funds on a transferable basis from ERS's appropriated funds. In 1990, $1.5 million will be transferred from ERS's appropriated budget to NASS for pesticide use data surveys.

International Affairs & Commodity Programs

Agricultural Stabilization and Conservation Service

Established in 1961, the Agricultural Stabilization and Conservation Service administers commodity and land use programs which not only protect the Nation's natural resources but also stabilize agricultural production, price, market, and farm income.

ASCS Tables. ASCS water-quality funding includes $50 million, in FY 1980, and $20 million, in FY 1981, for the experimental Rural Clean Water Program--which funded 21 long-term projects. ASCS water-quality FTE's are unidentifiable for the decade, 1980-1990. Additionally, the FTE totals are the summation of both Commodity Credit Corporation (CCC) and ASCS workloads, and ASCS $ totals do not include moneys transferred from CCC's appropriated funds to ASCS for salaries and expenses; hence, no relationship can be demonstrated between $ totals and FTE totals (Table 7).

Small Community and Rural Development

Farmers Home Administration (FmHA)

Guided by the Consolidated Farm and Rural Development Act of 1949, the Farmers Home Administration provides reasonable credit rates and terms on loans to rural residents and their communities through out the United States. FmHA does not conduct research, technology transfer, public information, nor educational activities related to water quality. FmHA does, however, operate several significant loan and grant programs designed to positively affect the quality, conservation, and use of water on farms and rural communities.[71]

FmHA Tables. FmHA WQ FTE's for 1980 and 1981 are not available by individual programs. The $ WQ figures are obligations for fiscal years, 1980-1988; 1989 and 1990 $ totals are budgetary estimates not obligations. Water-quality $ figures represent loans for Resource Conservation and Development; Soil and Water; Water and Waste Disposal Systems for Rural Communities; and Watershed and Flood Prevention.

TABLE 1 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Water Quality Base Funding for Agencies

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEAR:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	b/ 1990
Science & Education:												
ARS	$ WQ	16,100.0	16,700.0	17,200.0	19,000.0	19,300.0	19,500.0	20,200.0	22,400.0	24,400.0	30,000.0	40,000.0
	$ TOTAL	372,970.0	426,831.0	425,938.0	460,626.0	478,206.0	492,906.0	478,372.0	518,237.0	540,684.0	563,381.0	581,118.0
CSRS a/	$ WQ	12,465.0	13,519.0	14,840.0	15,704.0	16,025.0	16,470.0	15,894.0	15,894.0	16,470.0	19,720.0	23,556.0
	$ TOTAL	186,031.0	200,897.0	221,216.0	244,966.0	247,655.0	304,316.0	282,652.0	346,473.0	349,169.0	338,067.0	295,398.0
ES e/	$ WQ	—	—	—	—	—	—	14,800.0	14,800.0	14,800.0	16,300.0	21,300.0
	$ TOTAL	285,100.0	303,500.0	315,300.0	328,654.0	334,340.0	343,700.0	328,009.0	338,972.0	357,963.0	361,370.0	324,840.0
NAL f/	$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	250.0
	$ TOTAL	7,917.0	8,822.0	8,053.0	8,732.0	10,382.0	11,464.0	10,787.0	11,098.0	12,194.0	14,268.0	14,947.0
Natural Resources & Environment:												
FS	$ WQ	21,893.0	18,812.0	16,444.0	16,242.0	17,371.0	18,413.0	17,711.0	19,835.0	21,700.0	27,800.0	23,600.0
	$ TOTAL	1,634,381.0	1,709,374.0	1,520,119.0	1,647,667.0	1,388,905.0	1,450,744.0	1,589,063.0	1,714,162.0	1,757,483.0	2,247,032.0	2,305,648.0
SCS	$ WQ	500.0	500.0	1,400.0	2,700.0	3,800.0	5,500.0	7,900.0	7,900.0	11,400.0	13,700.0	26,700.0
	$ TOTAL	537,899.0	588,233.0	564,079.0	720,754.0	621,894.0	621,017.0	674,225.0	642,995.0	686,560.0	704,037.0	631,390.0
Marketing & Inspection Services:												
APHIS d/	$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11,952.0	13,284.0	13,383.0	13,383.0
	$ TOTAL	245,631.0	289,371.0	284,967.0	277,620.0	276,666.0	300,918.0	304,923.0	311,467.0	329,490.0	331,207.0	332,756.0
Economics:												
ERS g/ j/	$ WQ	—	—	—	—	500.0	500.0	550.0	550.0	800.0	800.0	3,250.0
	$ TOTAL	36,492.0	39,487.0	39,360.0	38,966.0	44,329.0	45,553.0	44,045.0	44,977.0	48,186.0	[illegible]	51,714.0
NASS g/	$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	$ TOTAL	49,009.0	53,787.0	51,446.0	51,830.0	54,430.0	58,287.0	56,200.0	57,889.0	61,176.0	63,588.0	71,038.0
International Affairs & Commodity Programs:												
ASCS i/	$ WQ	58,400.0	27,000.0	3,700.0	4,000.0	3,700.0	3,200.0	2,900.0	2,500.0	10,700.0	16,700.0	16,557.0
i/	$ TOTAL	494,780.0	453,034.0	277,709.0	274,262.0	284,441.0	262,009.0	216,096.0	205,649.0	1,289,179.0	2,011,722.0	1,220,420.0
Small Community & Rural Development:												
FmHA c/	$ WQ	1,065,000.0	1,029,000.0	535,500.0	927,300.0	386,400.0	481,500.0	449,900.0	452,700.0	454,500.0	464,200.0	325,000.0
	$ TOTAL	12,910,710.0	13,914,673.0	8,762,059.0	7,304,000.0	7,980,000.0	9,501,253.0	6,999,334.0	5,795,733.0	5,151,060.0	8,274,915.0	4,776,950.0

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

—— No data available.

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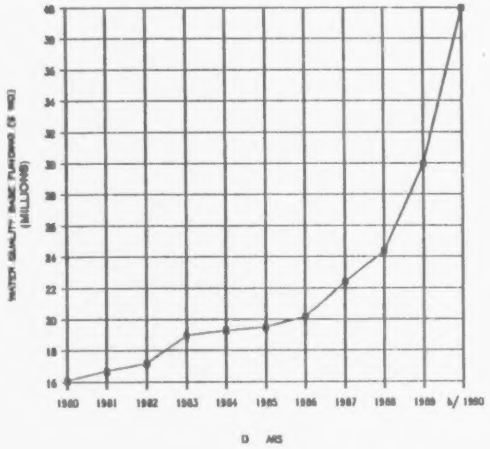
TABLE 1 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

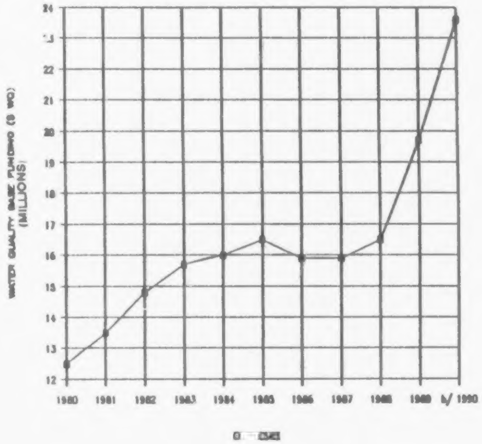
Water Quality Base Funding for Agencies

1980–1990

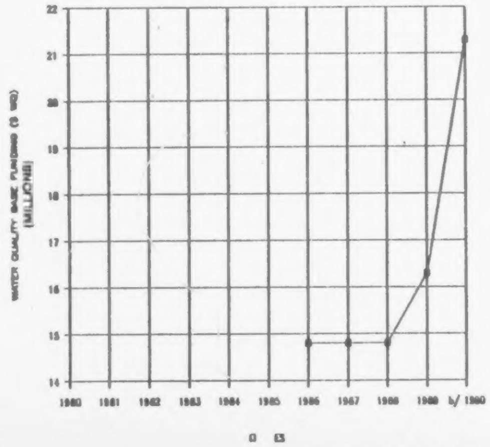
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

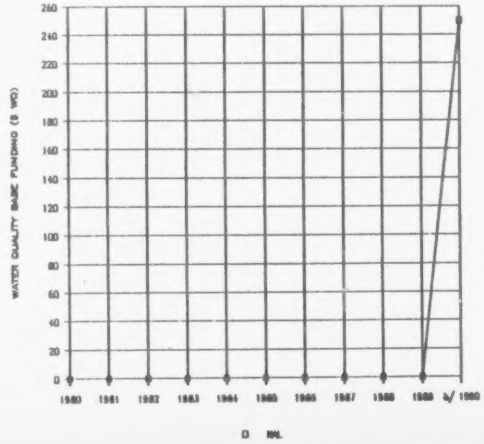


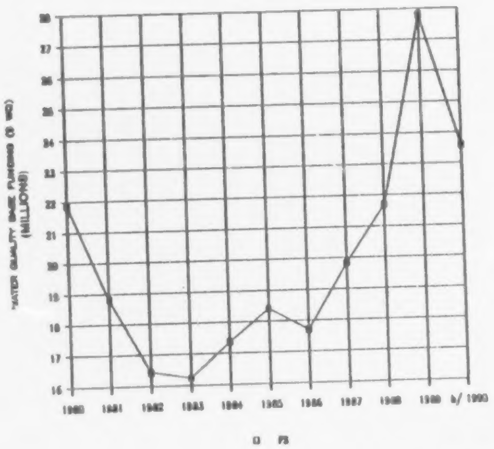
TABLE 1 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

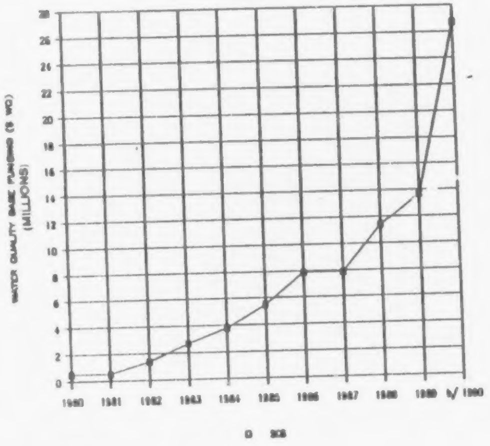
Water Quality Base Funding for Agencies

1980-1990

FOREST SERVICE



SOIL CONSERVATION SERVICE



ANIMAL/PLANT HEALTH INSPECTION SERVICE

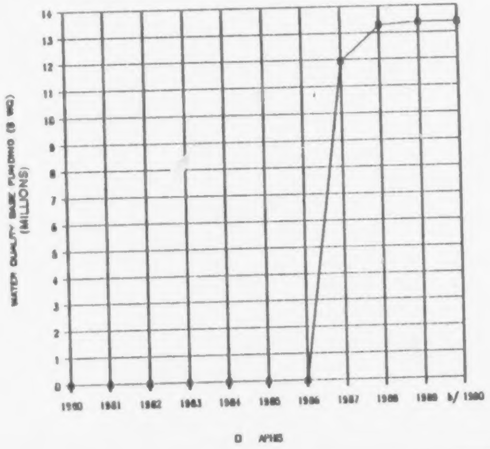


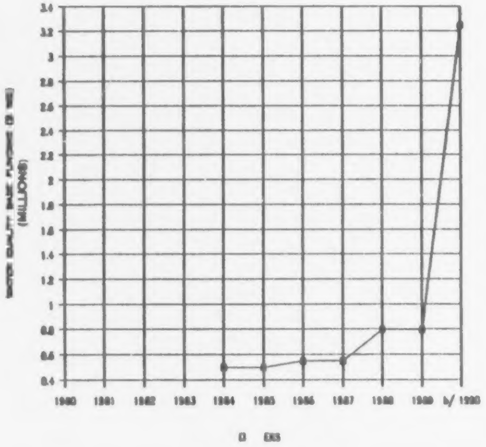
TABLE 1 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

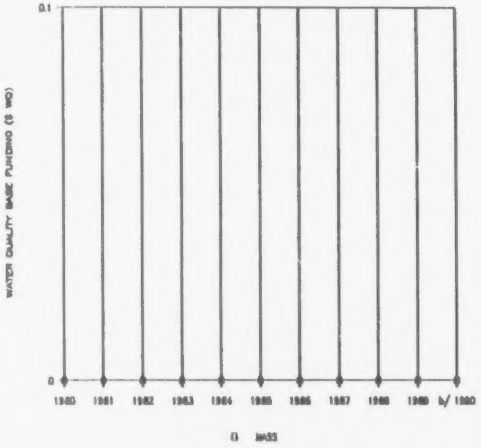
Water Quality Base Funding for Agencies

1980-1990

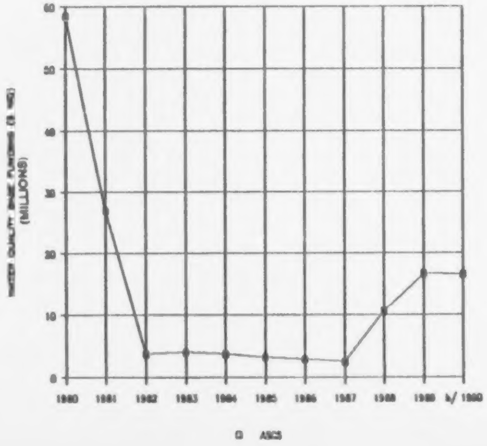
ECONOMIC RESEARCH SERVICE



NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE



FARMERS HOME ADMINISTRATION

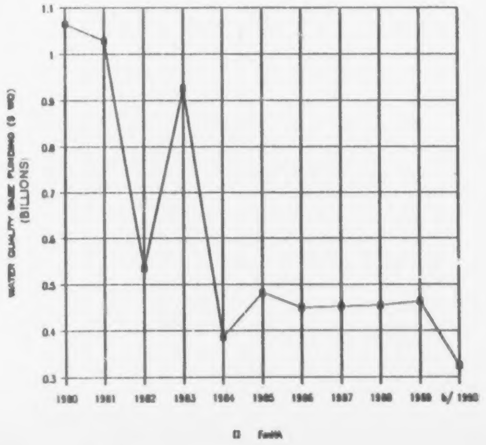


TABLE 2 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Adjusted Water Quality Funding Levels for Agencies

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEAR:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990/b
1982 GNP Deflator Index Values:		0.855	0.934	1	1.04	1.086	1.123	1.146	1.185	1.237	1.286	1.332
Science & Education:												
ARS	$ WQ	18,830.4	17,880.1	17,200.0	18,269.2	17,771.6	17,364.2	17,626.5	18,903.0	19,725.1	23,328.1	30,030.0
	$ TOTAL	436,222.2	456,992.5	425,938.0	442,909.6	440,337.0	438,919.0	417,427.6	437,330.8	437,093.0	438,087.9	436,274.8
CSRS a/	$ WQ	14,578.9	14,474.3	14,840.0	15,100.0	14,756.0	14,666.1	13,869.1	13,412.7	13,314.5	15,334.4	17,684.7
	$ TOTAL	217,580.1	215,093.1	221,216.0	235,544.2	228,043.3	270,984.9	246,642.2	292,382.3	282,270.8	262,882.6	221,770.3
ES e/	$ WQ	---	---	---	---	---	---	12,914.5	12,489.5	11,964.4	12,675.0	15,991.0
	$ TOTAL	333,450.3	324,946.5	315,300.0	316,013.5	307,863.7	306,055.2	286,220.8	286,052.3	289,380.0	281,003.1	243,873.9
NAL f/	$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	187.7
	$ TOTAL	9,259.6	9,445.4	8,053.0	8,396.2	9,559.9	10,208.4	9,412.7	9,365.4	9,857.7	11,094.9	11,221.5
Natural Resources & Environment:												
FS	$ WQ	25,605.8	20,141.3	16,444.0	15,617.3	15,995.4	16,396.3	15,454.6	16,738.4	17,542.4	21,617.4	17,717.7
	$ TOTAL	1,911,556.7	1,830,164.9	1,520,119.0	1,584,295.2	1,278,918.0	1,291,846.8	1,386,616.9	1,446,550.2	1,420,762.3	1,747,303.3	1,730,967.0
SCS	$ WQ	584.8	535.3	1,400.0	2,596.2	3,499.1	4,897.6	6,893.5	6,666.7	9,215.8	10,653.2	20,045.0
	$ TOTAL	629,121.6	629,799.8	564,079.0	693,032.7	572,646.4	552,998.2	588,329.0	542,611.8	555,020.2	547,462.7	474,016.5
Marketing & Inspection Services:												
APHIS d/	$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,086.1	10,738.9	10,406.7	10,047.3
	$ TOTAL	287,287.7	309,819.1	284,967.0	266,942.3	254,756.9	267,959.0	266,075.9	262,841.4	266,362.2	257,548.2	249,816.8
Economics:												
ERS g/ j/	$ WQ	---	---	---	---	460.4	445.2	479.9	464.1	646.7	622.1	2,439.9
	$ TOTAL	42,680.7	42,277.3	39,360.0	37,467.3	40,818.6	40,563.7	38,433.7	37,955.3	38,953.9	38,363.9	38,824.3
NASS g/	$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	$ TOTAL	57,320.5	57,587.8	51,446.0	49,836.5	50,119.7	51,902.9	49,040.1	48,851.5	49,455.1	49,446.3	53,331.8
International Affairs & Commodity Programs:												
ASCS i/	$ WQ	68,304.1	28,907.9	3,700.0	3,846.2	3,407.0	2,849.5	2,530.5	2,109.7	8,650.0	12,986.0	12,430.2
i/	$ TOTAL	578,690.1	485,047.1	277,709.0	263,713.5	261,916.2	233,311.7	188,565.4	173,543.5	1,042,181.9	1,564,325.0	916,231.2
Small Community & Rural Development:												
FmHA c/	$ WQ	1,245,614.0	1,101,713.1	535,500.0	891,634.6	355,801.1	428,762.2	392,582.9	382,025.3	367,421.2	360,964.2	243,994.0
	$ TOTAL	15,100,245.6	14,897,936.8	8,762,059.0	7,023,076.9	7,348,066.3	8,460,599.3	6,107,621.3	4,890,913.9	4,164,155.2	6,434,615.1	3,586,298.8

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

—— No data available.

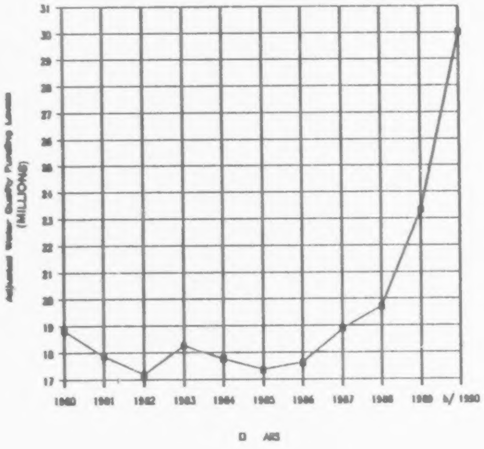
TABLE 2 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

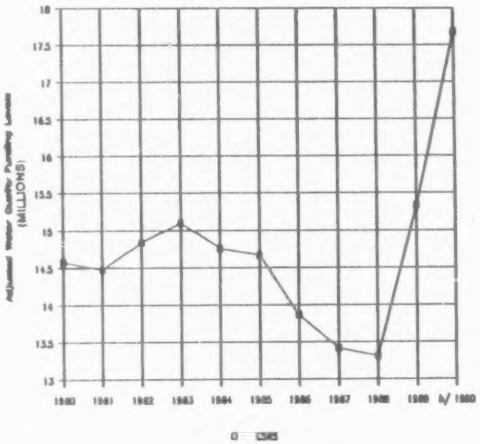
Adjusted Water Quality Funding Levels for Agencies

1980–1990

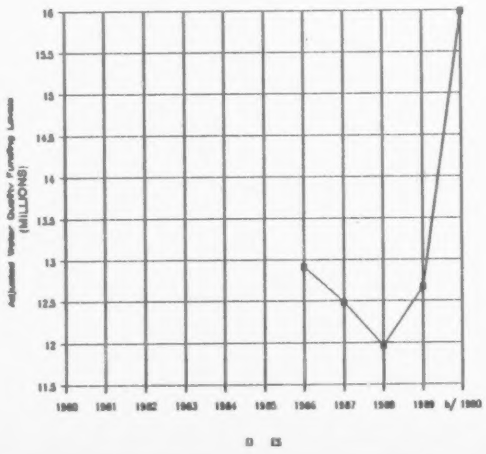
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



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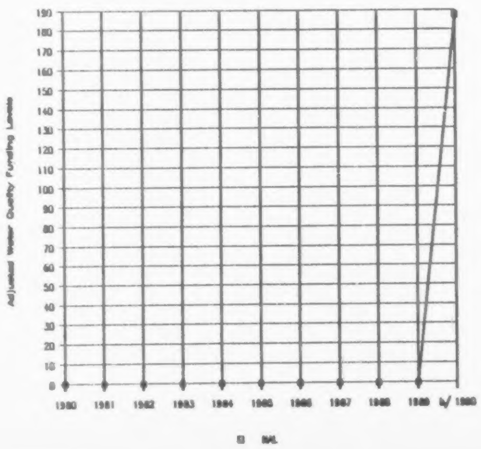


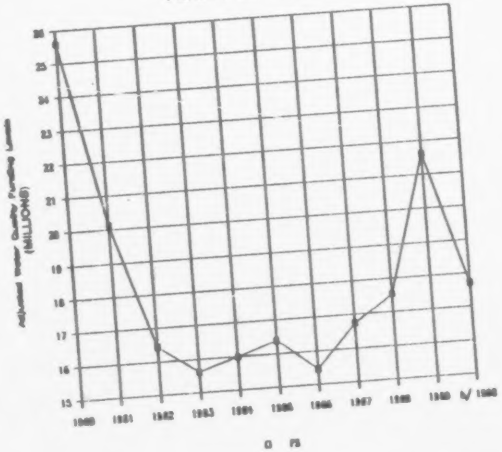
TABLE 2 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

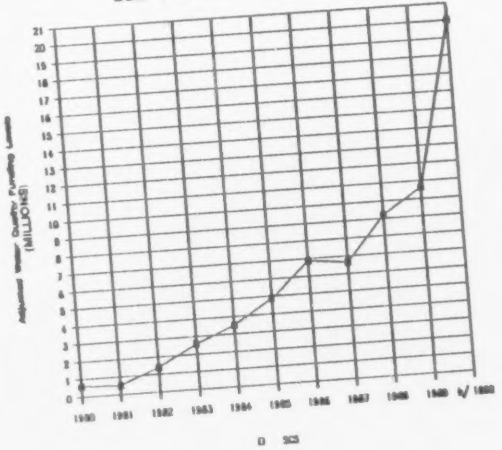
Adjusted Water Quality Funding Levels for Agencies

1980–1990

FOREST SERVICE



SOIL CONSERVATION SERVICE



ANIMAL/PLANT HEALTH INSPECTION SERVICE

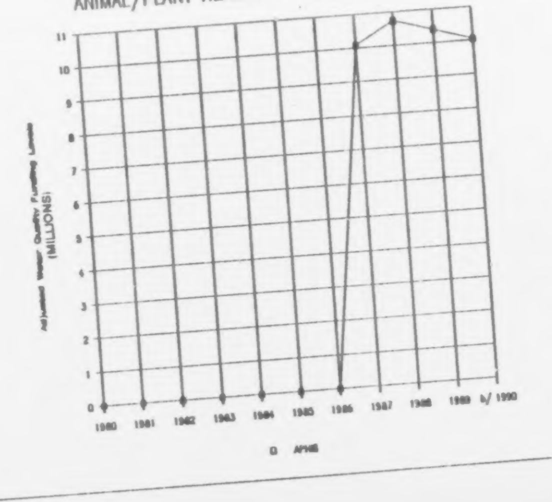


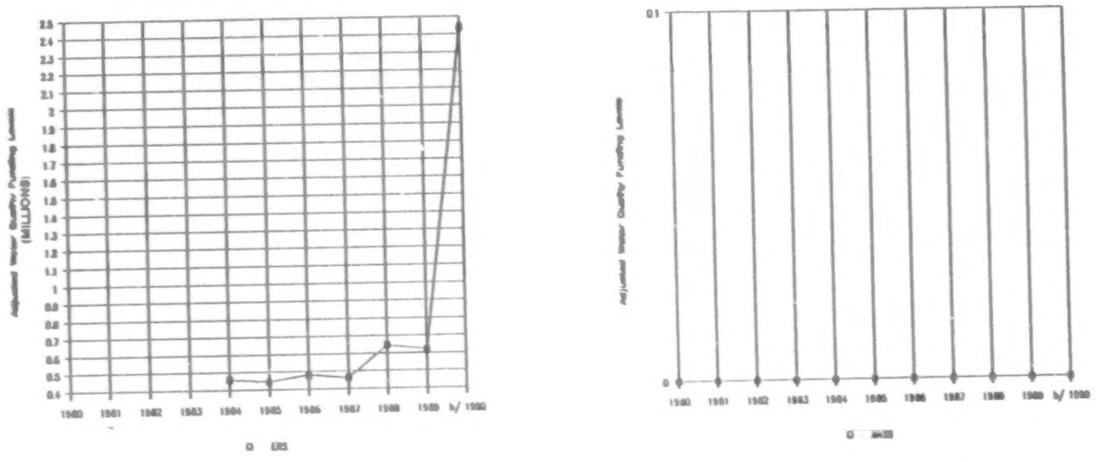
TABLE 2 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

Adjusted Water Quality Funding Levels for Agencies

1980–1990

ECONOMIC RESEARCH SERVICE NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE FARMERS HOME ADMINISTRATION

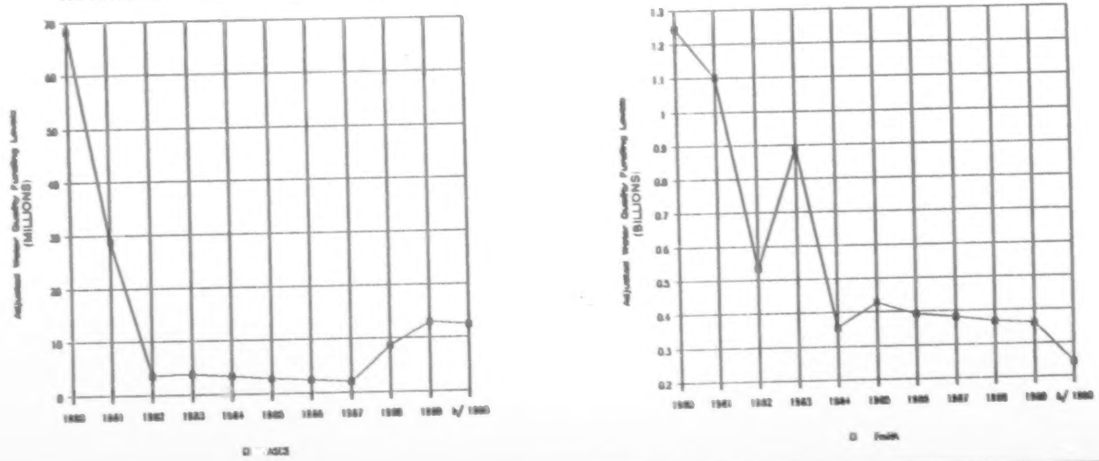


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TABLE 3 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Water Quality Personnel Resources for Agencies

1980–1990

WQ = Water Quality FTE = Full-Time Equivalents

YEAR:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Science & Education:												
ARS	FTE WQ	187	205	192	212	235	227	235	260	284	346	395
	FTE TOTAL	8,647	8,375	8,258	8,234	8,000	8,020	7,859	7,965	7,978	7,969	8,022
CSRS a/	FTE WQ	2	2	2	2	2	2	2	2	2	2	2
	FTE TOTAL	137	147	134	121	120	128	140	142	155	140	150
ES e/	FTE WQ	—	—	—	—	—	—	—	3	3	3	3
	FTE TOTAL	177	211	191	176	172	174	179	173	173	173	173
NAL l/	FTE WQ	0	0	0	0	0	0	0	0	0	0	1
	FTE TOTAL	193	197	191	171	153	160	177	178	190	190	191
Natural Resources & Environment:												
FS	FTE WQ	619	518	431	370	379	385	370	373	329	357	360
	FTE TOTAL	40,626	39,062	36,782	33,851	32,523	31,900	30,507	29,851	29,441	31,064	31,549
SCS h/	FTE WQ	31	35	67	97	226	299	273	257	284	245	441
	FTE TOTAL	15,167	14,764	14,028	14,156	13,959	13,612	12,895	12,395	13,747	13,794	13,143
Marketing & Inspection Services:												
APHIS d/	FTE WQ	0	0	0	0	0	0	0	171	193	191	221
	FTE TOTAL	4,823	4,400	5,099	4,700	4,722	4,812	5,012	5,109	5,244	5,480	5,389
Economics:												
ERS j/	FTE WQ	—	—	—	—	7	7	7	7	10	10	11
	FTE TOTAL	1,039	993	946	903	876	866	846	813	791	860	850
NASS	FTE WQ	0	0	0	0	0	0	0	0	0	0	0
	FTE TOTAL	1,273	1,145	1,093	1,051	1,044	1,036	966	943	952	951	945
International Affairs & Commodity Programs:												
ASCS i/	FTE WQ	—	—	—	—	—	—	—	—	—	—	—
i/*	FTE TOTAL	2,836	2,607	2,484	2,606	2,779	2,816	2,936	3,171	3,288	3,334	3,359
Small Community & Rural Development:												
FmHA c/	FTE WQ	—	—	553	666	554	599	458	475	404	366	347
	FTE TOTAL	11,342	11,910	10,843	11,194	12,301	12,118	12,133	12,289	12,235	12,675	12,675

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

— No data available.

A.375

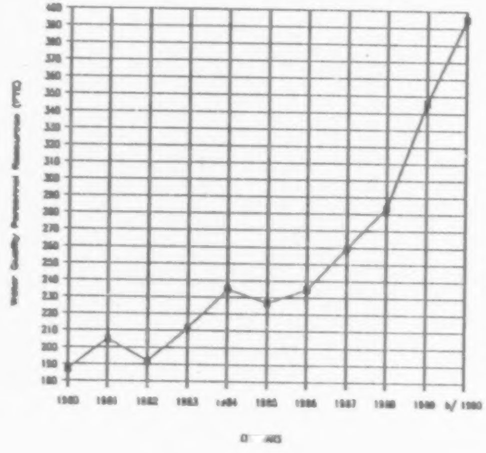
TABLE 3 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

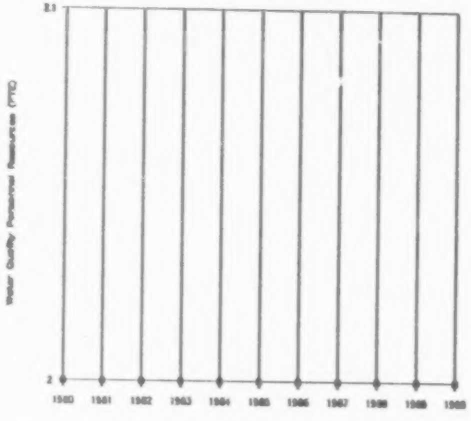
Water Quality Personnel Resources for Agencies

1980–1990

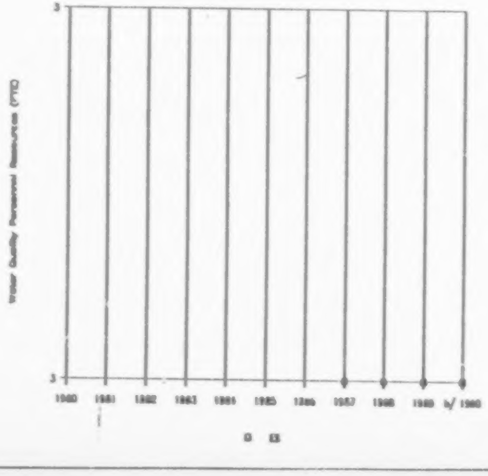
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

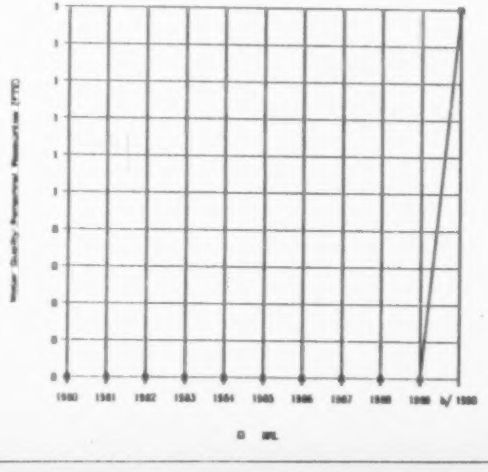


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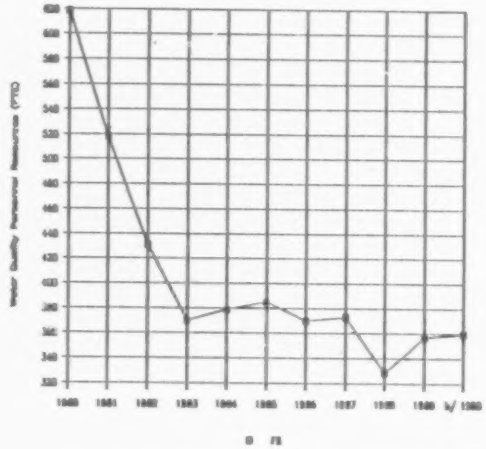
TABLE 3 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

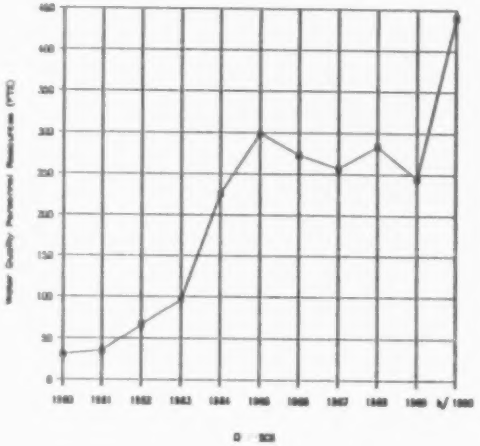
Water Quality Personnel Resources for Agencies

1980–1990

FOREST SERVICE



SOIL CONSERVATION SERVICE



ANIMAL/PLANT HEALTH INSPECTION SERVICE

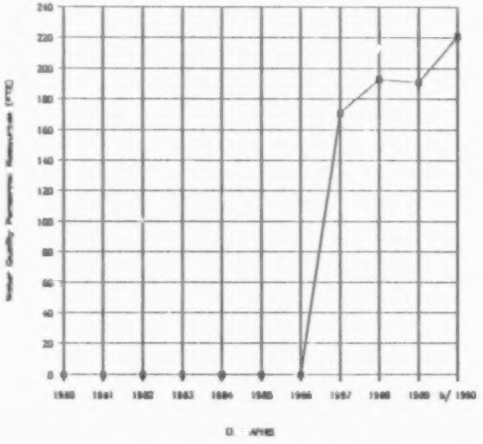
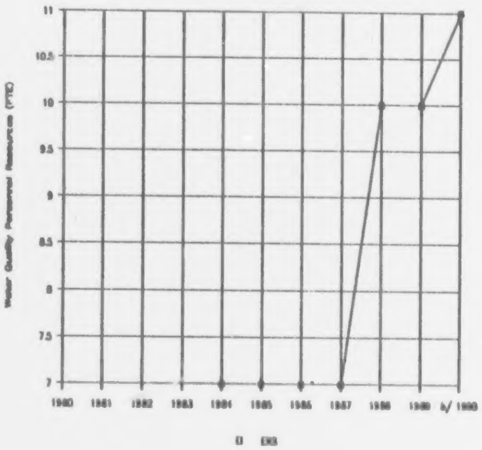


TABLE 3 GRAPHS:

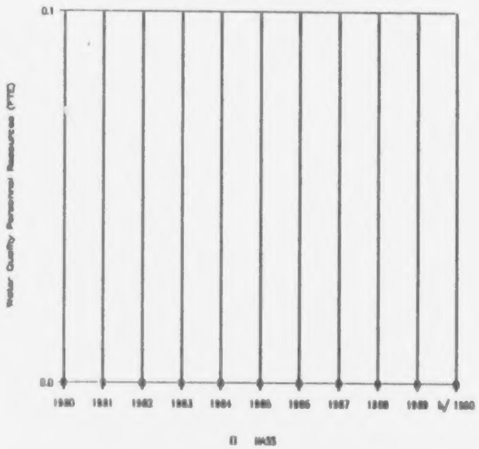
UNITED STATES DEPARTMENT OF AGRICULTURE
Water Quality Personnel Resources for Agencies

1980-1990

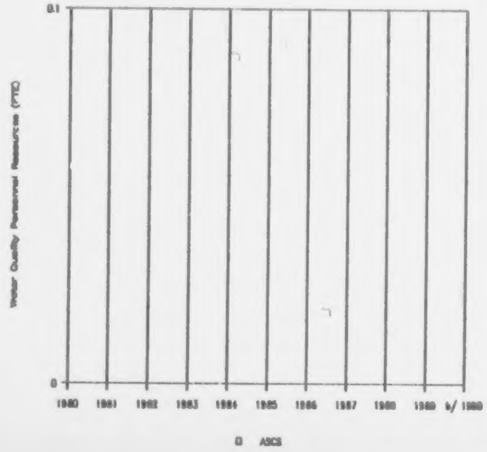
ECONOMIC RESEARCH SERVICE



NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE



FARMERS HOME ADMINISTRATION

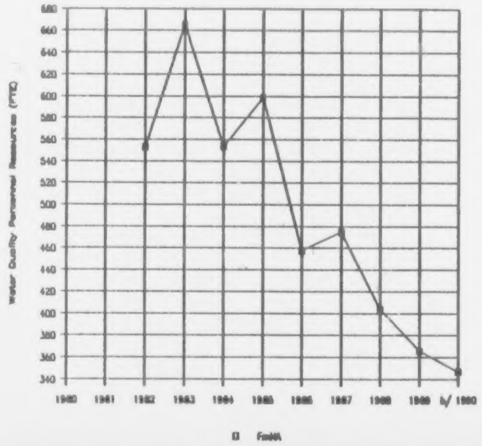


TABLE 4 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Percentage of Adjusted Funding Directed to Water Quality for Agencies

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990/b
Science & Education:											
ARS											
$ WQ	18,830.4	17,880.1	17,200.0	18,269.2	17,771.6	17,364.2	17,626.5	18,903.0	19,725.1	23,328.1	30,030.0
$ TOTAL	436,222.2	456,992.5	425,938.0	442,909.6	440,337.0	438,919.0	417,427.6	437,330.8	437,093.0	438,087.9	436,274.8
$ WQ/$ TOTAL (%)	4.3	3.9	4.0	4.1	4.0	4.0	4.2	4.3	4.5	5.3	6.9
CSRS											
a/ $ WQ	14,578.9	14,474.3	14,840.0	15,100.0	14,756.0	14,666.1	13,869.1	13,412.7	13,314.5	15,334.4	17,684.7
$ TOTAL	217,543.9	215,096.4	221,200.0	235,576.9	228,084.7	270,970.6	246,684.1	292,405.1	282,295.9	268,740.3	221,771.8
$ WQ/$ TOTAL (%)	6.7	6.7	6.7	6.4	6.5	5.4	5.6	4.6	4.7	5.7	8.0
ES											
e/ $ WQ	---	---	---	---	---	---	21,640.5	20,928.3	20,452.7	20,451.0	23,498.5
$ TOTAL	333,450.3	324,946.5	315,300.0	316,013.5	307,863.7	306,055.2	286,220.8	286,052.3	289,380.0	281,003.1	243,873.9
$ WQ/$ TOTAL (%) #							7.6	7.3	7.1	7.3	9.6
NAL											
$ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	187.7
$ TOTAL	9,259.6	9,445.4	8,053.0	8,396.2	9,559.9	10,208.4	9,412.7	9,365.4	9,857.7	11,094.9	11,221.5
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
Natural Resources & Environment:											
FS											
$ WQ	25,605.8	20,141.3	16,444.0	15,617.3	15,995.4	16,396.3	15,454.6	16,738.4	17,542.4	21,617.4	17,717.7
$ TOTAL	1,911,556.7	1,830,164.9	1,520,119.0	1,584,295.2	1,278,918.0	1,291,846.8	1,386,616.9	1,446,550.2	1,420,762.3	1,747,303.3	1,730,967.0
$ WQ/$ TOTAL (%)	1.3	1.1	1.1	1.0	1.3	1.3	1.1	1.2	1.2	1.2	1.0
SCS											
$ WQ	584.8	535.3	1,400.0	2,596.2	3,499.1	4,897.6	6,893.5	6,666.7	9,215.8	10,653.2	20,045.0
$ TOTAL	629,121.6	629,799.8	564,079.0	693,032.7	572,646.4	552,998.2	588,329.0	542,611.8	555,020.2	547,462.7	474,016.5
$ WQ/$ TOTAL (%)	0.1	0.1	0.2	0.4	0.6	0.9	1.2	1.2	1.7	1.9	4.2
Marketing & Inspection Services:											
APHIS											
d/ $ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,086.1	10,738.9	10,406.7	10,047.3
$ TOTAL	287,287.7	309,819.1	284,967.0	266,942.3	254,756.9	267,959.0	266,075.9	262,841.4	266,362.2	257,548.2	249,816.8
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	4.0	4.0	4.0
Economics:											
ERS											
g/ $ WQ	---	---	---	---	460.4	445.2	479.9	464.1	646.7	622.1	2,439.9
$ TOTAL	42,680.7	42,277.3	39,360.0	37,467.3	40,818.6	40,563.7	38,433.7	37,955.3	38,953.9	38,363.9	38,824.3
$ WQ/$ TOTAL (%) #					1.1	1.1	1.2	1.2	1.7	1.6	6.3
NASS											
g/ $ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	57,320.5	57,587.8	51,446.0	49,836.5	50,119.7	51,902.9	49,040.1	48,851.5	19,455.1	49,446.3	53,331.8
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
International Affairs & Commodity Programs:											
ASCS											
i/ $ WQ	68,304.1	28,907.9	3,700.0	3,846.2	3,407.0	2,849.5	2,530.5	2,109.7	8,650.0	12,986.0	12,430.2
i/ $ TOTAL	578,690.1	485,047.1	277,709.0	263,713.5	261,916.2	233,311.7	188,565.4	173,543.5	1,042,181.9	1,564,325.0	916,231.2
$ WQ/$ TOTAL (%)	11.8	6.0	1.3	1.5	1.3	1.2	1.3	1.2	0.8	0.8	1.4
Small Community & Rural Development:											
FmHA											
c/ $ WQ	1,245,614.0	1,101,713.1	535,500.0	891,634.6	355,801.1	428,762.2	392,582.9	382,025.3	367,421.2	360,964.2	243,994.0
$ TOTAL	15,100,245.6	14,897,936.8	8,762,059.0	7,023,076.9	7,348,066.3	8,460,599.3	6,107,621.3	4,890,913.9	4,164,155.2	6,434,615.1	3,586,298.8
$ WQ/$ TOTAL (%)	8.2	7.4	6.1	12.7	4.8	5.1	6.4	7.8	8.8	5.6	6.8

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

--- No data available.

Because the numerator or denominator of the intended numerical ratio is unknown, no numerical relationship can be demonstrated in the empty cells.

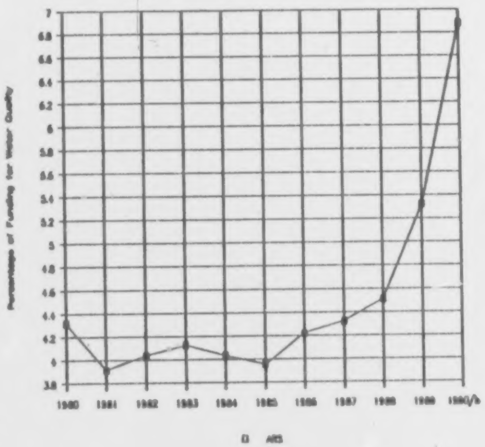
TABLE 4 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

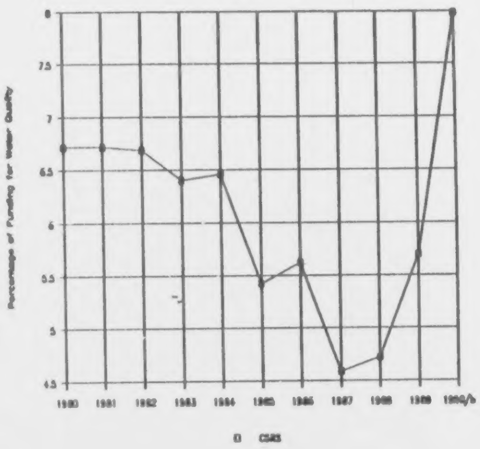
Percentage of Adjusted Funding Directed to Water Quality for Agencies

1980–1990

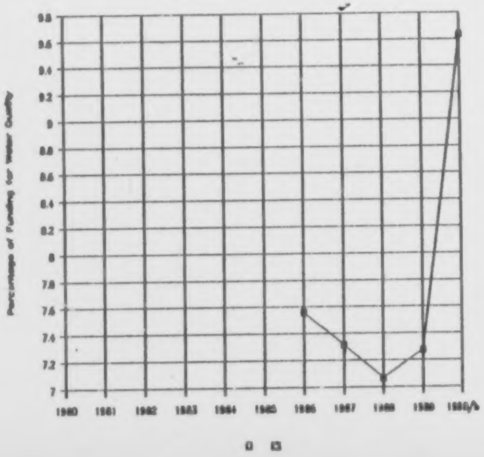
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

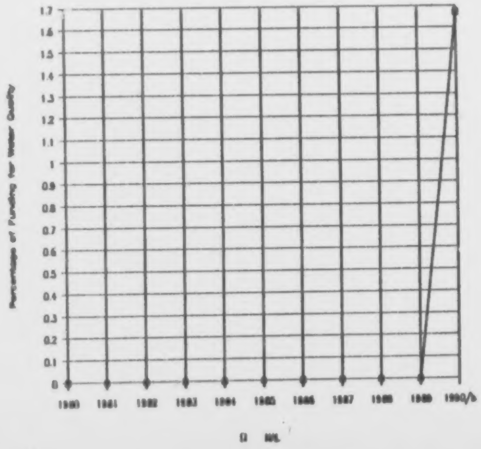


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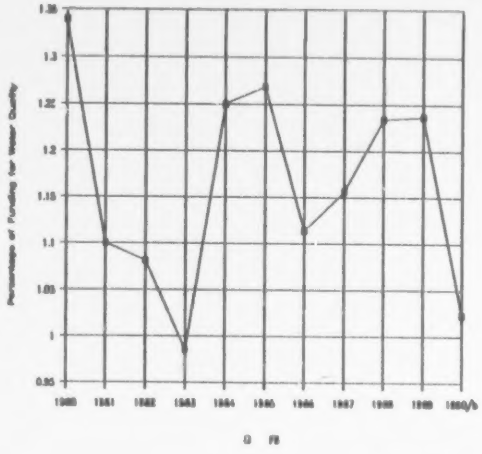
TABLE 4 GRAPHS:

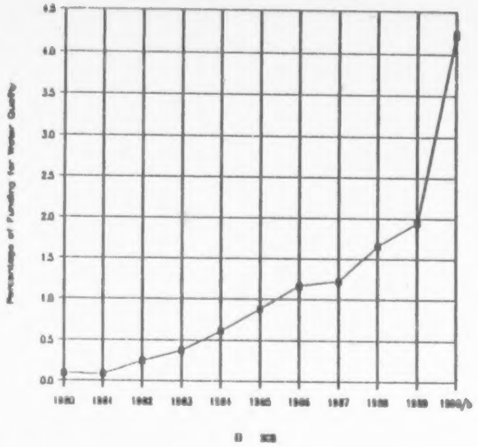
UNITED STATES DEPARTMENT OF AGRICULTURE
Percentage of Adjusted Funding Directed to Water Quality for Agencies

1980–1990

FOREST SERVICE



SOIL CONSERVATION SERVICE



ANIMAL/PLANT HEALTH INSPECTION SERVICE

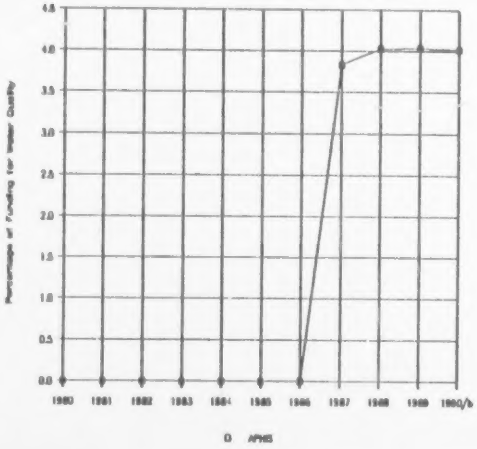


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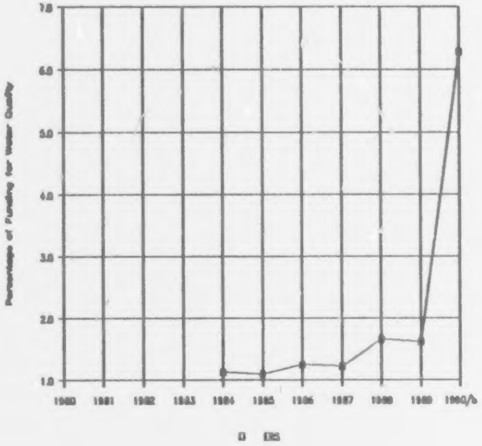
TABLE 4 GRAPHS:

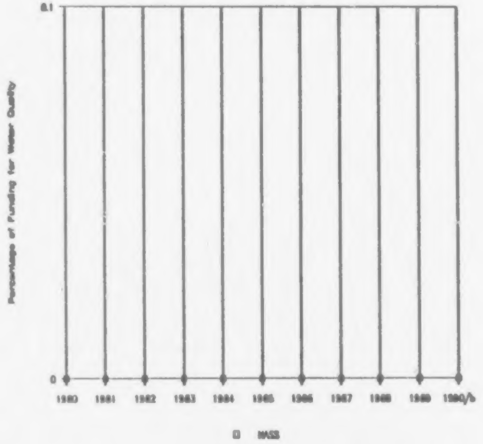
UNITED STATES DEPARTMENT OF AGRICULTURE
Percentage of Adjusted Funding Directed to Water Quality for Agencies

1980–1990

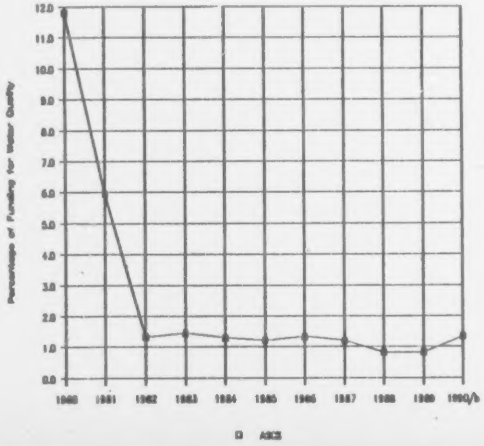
ECONOMIC RESEARCH SERVICE



NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE



FARMERS HOME ADMINISTRATION

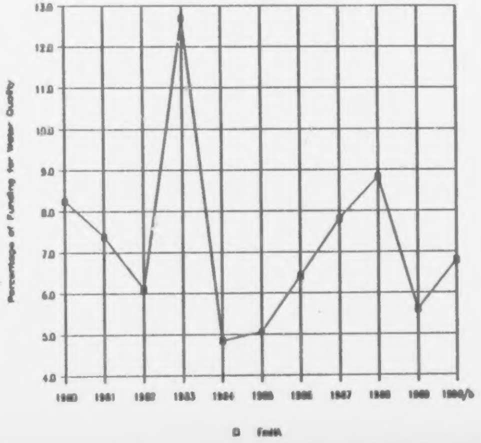


TABLE 5 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Percentage of Total Personnel Assigned to Water Quality for Agencies
1980–1990

WQ = Water Quality FTE = Full-Time Equivalents

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Science & Education:											
ARS											
FTE WQ	187	205	192	212	235	227	235	260	284	346	395
FTE TOTAL	8,647	8,375	8,268	8,234	8,000	8,020	7,859	7,965	7,978	7,969	8,022
FTE WQ/FTE TOTAL (%)	2.2	2.4	2.3	2.6	2.9	2.8	3.0	3.3	3.6	4.3	4.9
CSRS											
a/ FTE WQ	2	2	2	2	2	2	2	2	2	2	2
FTE TOTAL	137	147	134	121	120	128	140	142	155	140	150
FTE WQ/FTE TOTAL (%)	1.5	1.4	1.5	1.7	1.7	1.6	1.4	1.4	1.3	1.4	1.3
ES											
e/ FTE WQ	----	----	----	----	----	----	----	3	3	3	3
FTE TOTAL	177	211	191	176	172	174	179	173	173	173	173
FTE WQ/FTE TOTAL (%) #								1.7	1.7	1.7	1.7
NAL											
i/ FTE WQ	0	0	0	0	0	0	0	0	0	0	1
FTE TOTAL	193	197	191	171	153	160	177	176	190	190	191
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Natural Resources & Environment:											
FS											
FTE WQ	619	518	431	370	379	385	370	373	329	357	360
FTE TOTAL	40,626	39,062	36,782	33,851	32,523	31,900	30,507	29,851	29,441	31,064	31,549
FTE WQ/FTE TOTAL (%)	1.5	1.3	1.2	1.1	1.2	1.2	1.2	1.2	1.1	1.1	1.1
SCS											
h/ FTE WQ	31	35	67	97	226	299	273	257	284	245	441
FTE TOTAL	15,167	14,764	14,028	14,156	13,959	13,612	12,895	12,395	13,747	13,794	14,177
FTE WQ/FTE TOTAL (%)	0.2	0.2	0.5	0.7	1.6	2.2	2.1	2.1	2.1	1.8	3.1
Marketing & Inspection Services:											
APHIS											
d/ FTE WQ	0	0	0	0	0	0	0	171	193	191	221
FTE TOTAL	4,823	4,400	5,099	4,700	4,722	4,812	5,012	5,109	5,244	5,480	5,389
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	3.7	3.5	4.1
Economics:											
ERS											
j/ FTE WQ	----	----	----	----	7	7	7	7	10	10	11
FTE TOTAL	1,039	993	946	903	876	866	846	813	791	860	850
FTE WQ/FTE TOTAL (%) #					0.8	0.8	0.8	0.9	1.3	1.2	1.3
NASS											
FTE WQ	0	0	0	0	0	0	0	0	0	0	0
FTE TOTAL	1,273	1,145	1,093	1,051	1,044	1,036	968	943	952	951	945
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
International Affairs & Commodity Programs:											
ASCS											
l/ FTE WQ	----	----	----	----	----	----	----	----	----	----	----
l/* FTE TOTAL	2,836	2,607	2,484	2,606	2,779	2,816	2,936	3,171	3,288	3,334	3,359
FTE WQ/FTE TOTAL (%) #											
Small Community & Rural Development:											
FmHA											
c/ FTE WQ	----	----	553	666	554	599	458	475	404	366	347
FTE TOTAL	11,342	11,910	10,843	11,194	12,301	12,118	12,133	12,289	12,235	12,675	12,675
FTE WQ/FTE TOTAL (%) #			5.1	5.9	4.5	4.9	3.8	3.9	3.3	2.9	2.7

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.
---- No data available.
Because the numerator or denominator of the intended numerical ratio is unknown, no numerical relationship can be demonstrated in the empty cells.

A. 383

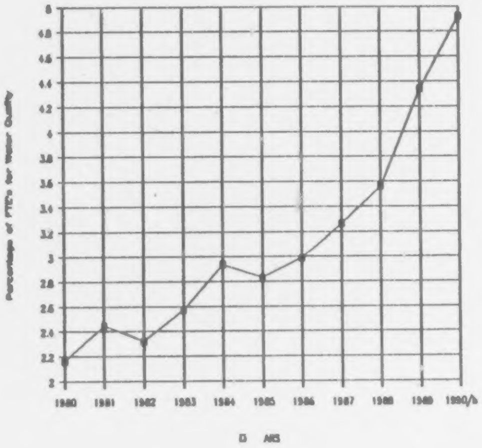
TABLE 5 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

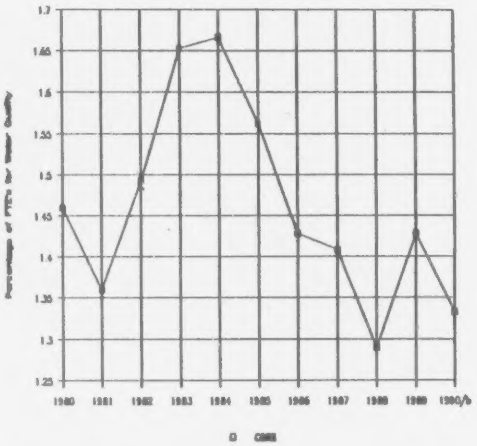
Percentage of Total Personnel Assigned to Water Quality for Agencies

1980–1990

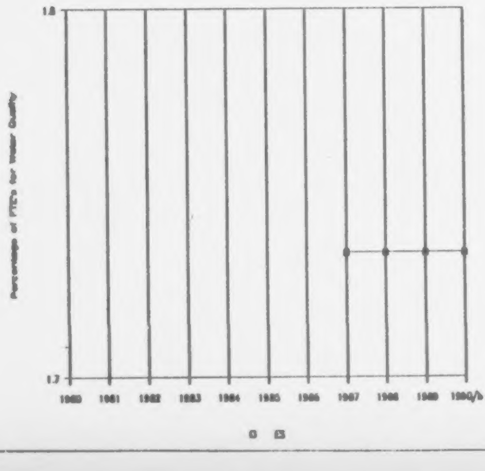
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

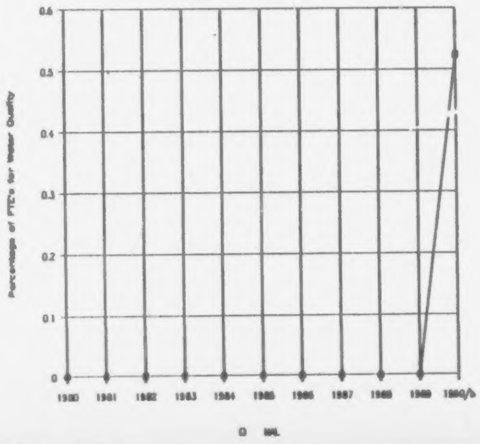


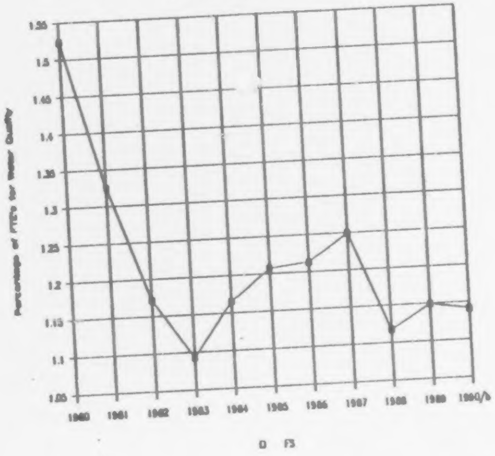
TABLE 5 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

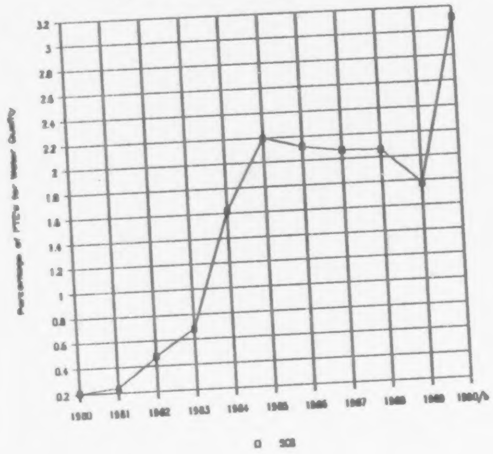
Percentage of Total Personnel Assigned to Water Quality for Agencies

1980–1990

FOREST SERVICE



SOIL CONSERVATION SERVICE



ANIMAL/PLANT HEALTH INSPECTION SERVICE

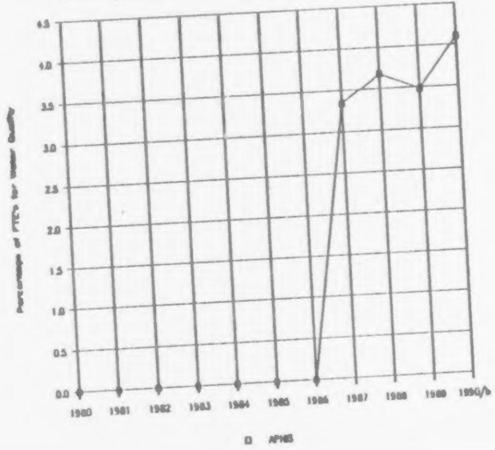
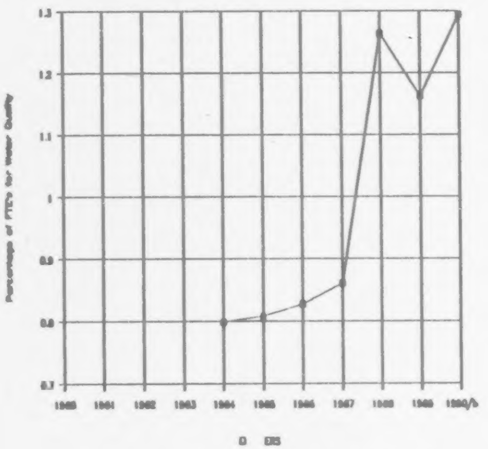


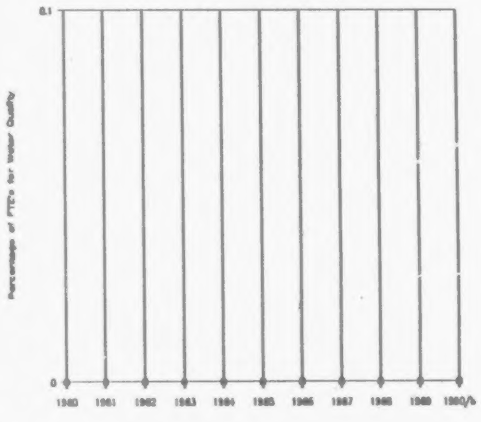
TABLE 5 GRAPHS:

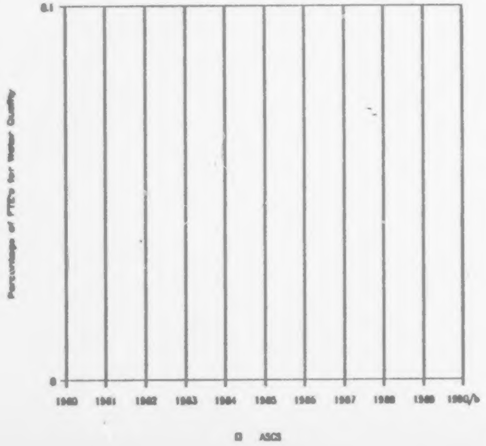
UNITED STATES DEPARTMENT OF AGRICULTURE

Percentage of Total Personnel Assigned to Water Quality for Agencies

1980–1990


ECONOMIC RESEARCH SERVICE


NATIONAL AG STATISTICS SERVICE


AG STABILIZATION & CONSERVATION SERVICE

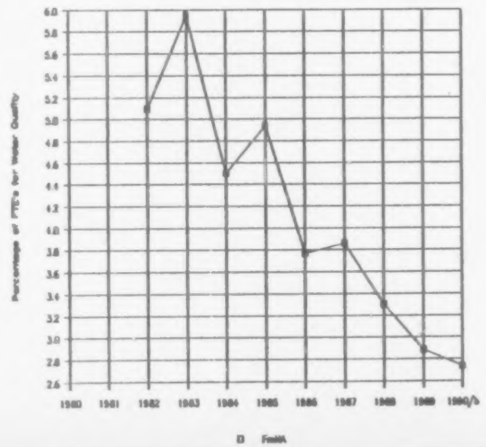

FARMERS HOME ADMINISTRATION

TABLE 6 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Agencies

1980-1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990/b
Science & Education:											
ARS											
$ WQ	18,830.4	17,880.1	17,200.0	18,269.2	17,771.6	17,364.2	17,626.5	18,903.0	19,725.1	23,328.1	30,030.0
FTE WQ	187	205	192	212	235	227	235	260	284	346	395
$ WQ/FTE WQ	100.7	87.2	89.6	86.2	75.6	76.5	75.0	72.7	69.5	67.4	76.0
CSRS											
a/ $ WQ	14,578.9	14,474.3	14,840.0	15,100.0	14,756.0	14,666.1	13,869.1	13,412.7	13,314.5	15,334.4	17,684.7
a/ FTE WQ	2	2	2	2	2	2	2	2	2	2	2
$ WQ/FTE WQ	7,289.5	7,237.2	7,420.0	7,550.0	7,378.0	7,333.0	6,934.6	6,706.3	6,657.2	7,667.2	8,842.3
ES											
e/ $ WQ	---	---	---	---	---	---	12,914.5	12,489.5	11,964.4	12,675.0	15,991.0
e/ FTE WQ	---	---	---	---	---	---	---	3	3	3	3
$ WQ/FTE WQ #								4,163.2	3,988.1	4,225.0	5,330.3
NAL											
i/ $ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	187.7
i/ FTE WQ	0	0	0	0	0	0	0	0	0	0	1
$ WQ/FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	187.7
Natural Resources & Environment:											
FS											
$ WQ	25,605.8	20,141.3	16,444.0	15,617.3	15,995.4	16,396.3	15,454.6	16,738.4	17,542.4	21,617.4	17,717.7
FTE WQ	619	518	431	370	379	385	370	373	329	357	360
$ WQ/FTE WQ	41.4	38.9	38.2	42.2	42.2	42.6	41.8	44.9	53.3	60.6	49.2
SCS											
$ WQ	584.8	535.3	1,400.0	2,596.2	3,499.1	4,897.6	6,893.5	6,666.7	9,216.8	10,653.2	20,045.0
h/ FTE WQ	31	35	67	97	226	299	273	257	284	245	441
$ WQ/FTE WQ	18.9	15.3	20.9	26.8	15.5	16.4	25.3	25.9	32.5	43.5	45.5
Marketing & Inspection Services:											
APHIS											
d/ $ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10,086.1	10,738.9	10,406.7	10,047.3
d/ FTE WQ	0	0	0	0	0	0	0	171	193	191	221
$ WQ/FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	59.0	55.6	54.5	45.5
Economics:											
ERS											
g/ j/ $ WQ	---	---	---	---	460.4	445.2	479.9	464.1	646.7	622.1	2,439.9
j/ FTE WQ	---	---	---	---	7	7	7	7	10	10	11
$ WQ/FTE WQ #					65.8	63.6	68.6	66.3	64.7	62.2	221.8
NASS											
g/ $ WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE WQ	0	0	0	0	0	0	0	0	0	0	0
$ WQ/FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
International Affairs & Commodity Programs:											
ASCS											
i/ $ WQ	68,304.1	28,907.9	3,700.0	3,846.2	3,407.0	2,849.5	2,530.5	2,109.7	8,650.0	12,986.0	12,430.2
i/ FTE WQ	---	---	---	---	---	---	---	---	---	---	---
$ WQ/FTE WQ #											
Small Community & Rural Development:											
FmHA											
c/ $ WQ	1,245,614.0	1,101,713.1	535,500.0	891,634.6	355,801.1	428,762.2	392,582.9	382,025.3	367,421.2	360,964.2	243,994.0
c/ FTE WQ	---	---	553	666	554	599	458	475	404	366	347
$ WQ/FTE WQ #			968.4	1338.8	642.2	715.8	857.2	804.3	909.5	986.2	703.2

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

--- No data available.

# Because the numerator or denominator of the intended numerical ratio is unknown, no numerical relationship can be demonstrated in the empty cells.

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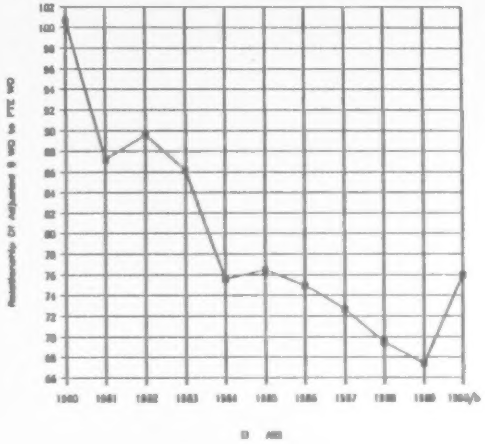
TABLE 6 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

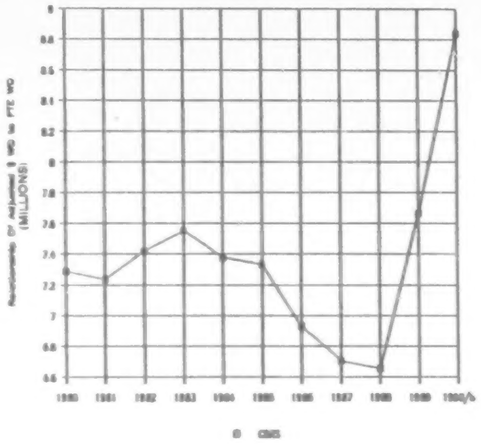
Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Agencies

1980-1990

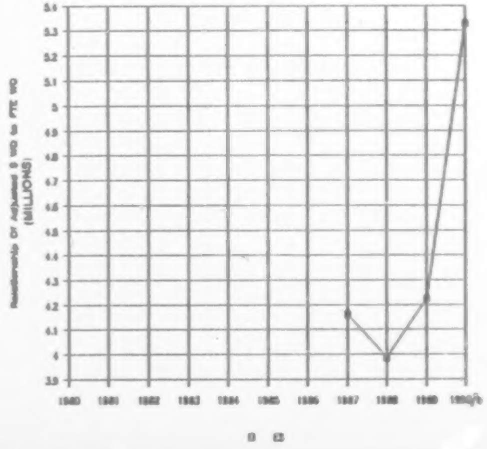
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

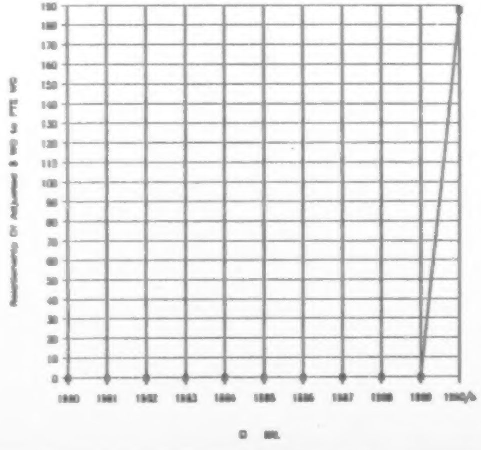


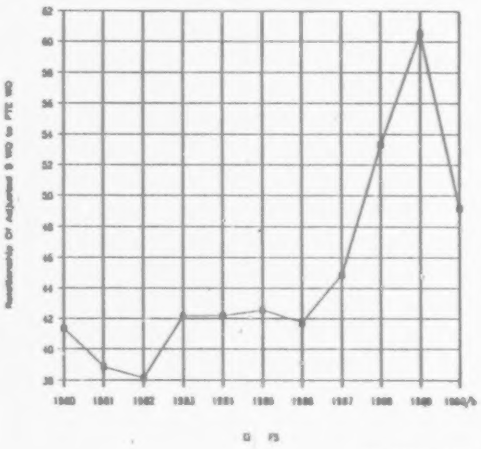
TABLE 6 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

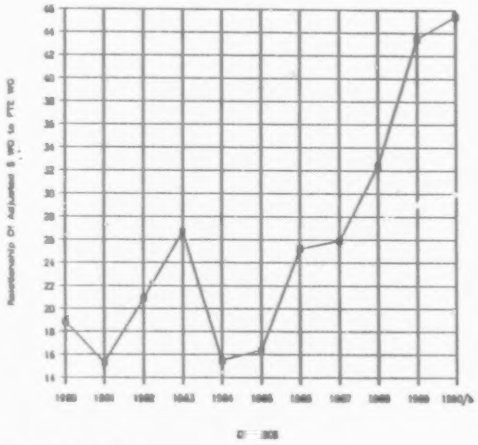
Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Agencies

1980-1990

FOREST SERVICE



SOIL CONSERVATION SERVICE .



ANIMAL/PLANT HEALTH INSPECTION SERVICE

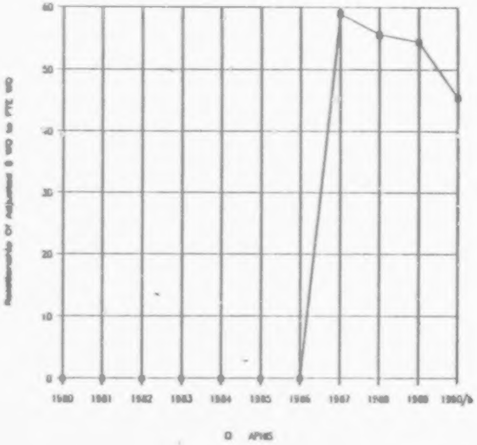


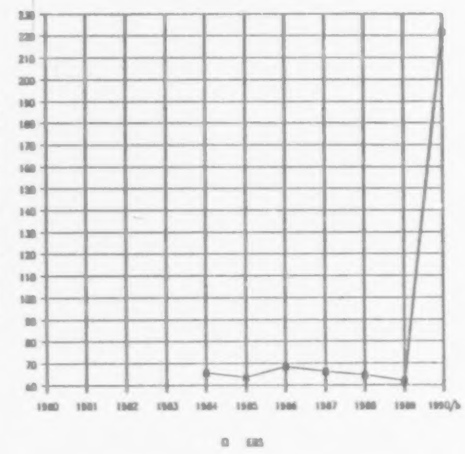
TABLE 6 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

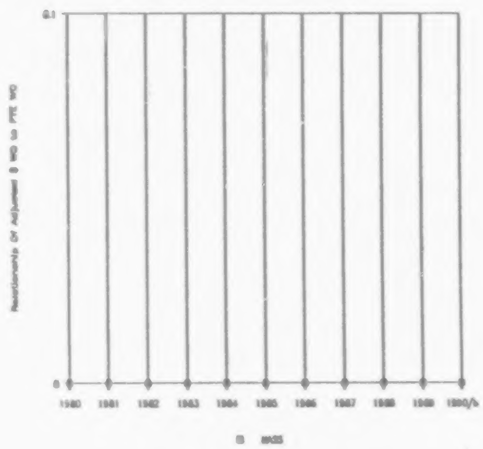
Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Agencies

1980–1990

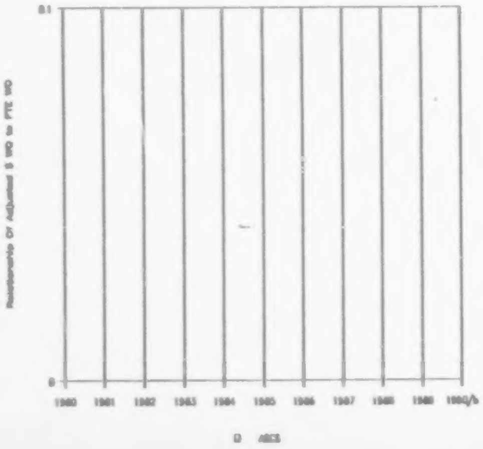
ECONOMIC RESEARCH SERVICE



NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE



FARMERS HOME ADMINISTRATION

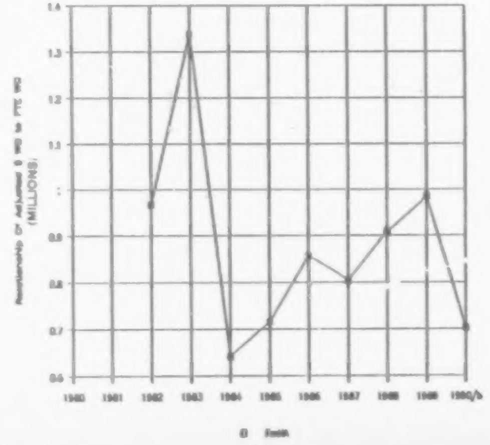


TABLE 7 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE

Relationship of Adjusted Total Funding to Total Personnel for Agencies

1980-1990

(Thousands of Dollars)

WQ = Water Quality　　$ = Appropriated Funds　　FTE = Full-Time Equivalents

	YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Science & Education:												
ARS												
	$ TOTAL	436,222.2	456,992.5	425,938.0	442,909.6	440,337.0	438,919.0	417,427.0	437,330.8	437,093.0	438,087.9	436,274.8
	FTE TOTAL	8,647	8,375	8,263	8,234	8,000	8,020	7,859	7,965	7,978	7,969	8,022
	$ TOTAL/FTE TOTAL	50.4	54.6	51.5	53.8	55.0	54.7	53.1	54.9	54.8	55.0	54.4
CSRS												
a/	$ TOTAL	217,580.1	215,093.1	221,218.0	235,544.2	228,043.3	270,984.9	246,642.2	292,382.3	282,270.8	262,882.6	221,770.3
a/	FTE TOTAL	137	147	134	121	120	128	140	142	155	140	150
	$ TOTAL/FTE TOTAL	1,588.2	1,463.2	1,650.9	1,946.6	1,900.4	2,117.1	1,761.7	2,059.0	1,821.1	1,877.7	1,478.5
ES												
e/	$ TOTAL	333,450.3	324,946.5	315,300.0	316,013.6	307,863.7	306,055.2	286,220.8	286,052.3	289,380.0	281,003.1	243,873.9
e/	FTE TOTAL	177	211	191	176	172	174	179	173	173	173	173
	$ TOTAL/FTE TOTAL	1,883.9	1,540.0	1,650.8	1,795.5	1,789.9	1,758.9	1,599.0	1,653.5	1,672.7	1,624.3	1,409.7
NAL												
i/	$ TOTAL	9,259.6	9,445.4	8,053.0	8,396.2	9,559.9	10,208.4	9,412.7	9,365.4	9,857.7	11,094.9	11,221.5
i/	FTE TOTAL	193	197	191	171	153	160	177	176	190	190	191
	$ TOTAL/FTE TOTAL	48.0	47.9	42.2	49.1	62.5	63.8	53.2	53.2	51.9	58.4	58.8
Natural Resources & Environment:												
FS												
	$ TOTAL	1,911,558.7	1,830,164.9	1,520,119.0	1,684,295.2	1,278,918.0	1,291,845.8	1,386,616.9	1,446,550.2	1,420,762.3	1,747,303.3	1,730,967.0
	FTE TOTAL	40,628	39,062	36,782	33,851	32,523	31,900	30,507	29,851	29,441	31,064	31,549
	$ TOTAL/FTE TOTAL	47.1	46.9	41.3	49.8	39.3	40.5	45.5	48.5	48.3	56.2	54.9
SCS												
	$ TOTAL	629,121.6	629,799.3	564,079.0	693,032.7	572,646.4	552,998.2	588,329.0	542,611.8	555,020.2	547,462.7	474,016.5
h/	FTE TOTAL	15,167	14,764	14,028	14,156	13,959	13,612	12,895	12,395	13,747	13,794	13,143
	$ TOTAL/FTE TOTAL	41.5	42.7	40.2	49.0	41.0	40.6	45.6	43.8	40.4	39.7	36.1
Marketing & Inspection Services:												
APHIS												
d/	$ TOTAL	287,287.7	309,819.1	284,967.0	266,942.3	254,756.9	267,959.0	266,075.9	262,841.4	266,362.2	257,548.2	249,816.8
d/	FTE TOTAL	4,823	4,400	5,099	4,700	4,722	4,812	5,012	5,109	5,244	5,480	5,389
	$ TOTAL/FTE TOTAL	59.6	70.4	55.9	56.8	54.0	55.7	53.1	51.4	50.8	47.0	46.4
Economics:												
ERS												
g/ j/	$ TOTAL	42,680.7	42,277.3	39,360.0	37,467.3	40,818.6	40,563.7	38,433.7	37,955.3	38,953.9	38,363.9	38,824.3
	FTE TOTAL	1,039	993	946	903	876	866	846	813	791	860	850
	$ TOTAL/FTE TOTAL	41.1	42.6	41.6	41.5	46.6	46.8	45.4	46.7	49.2	44.6	45.7
NASS												
g/	$ TOTAL	57,320.5	57,587.8	51,446.0	49,836.5	50,110.7	51,902.9	49,040.1	48,851.5	49,455.1	49,446.3	53,331.8
	FTE TOTAL	1,273	1,145	1,093	1,051	1,044	1,036	968	943	952	951	945
	$ TOTAL/FTE TOTAL	45.0	50.3	47.1	47.4	48.0	50.1	50.7	51.8	51.9	52.0	56.4
International Affairs & Commodity Programs:												
ASCS												
k/	$ TOTAL	578,690.1	485,047.1	277,709.0	263,713.5	261,916.2	233,311.7	188,565.4	173,543.5	1,042,181.9	1,564,325.0	916,231.2
k/*	FTE TOTAL	2,836	2,607	2,484	2,606	2,779	2,816	2,936	3,171	3,288	3,334	3,359
	$ TOTAL/FTE TOTAL	204.1	186.1	111.8	101.2	94.2	82.9	64.2	54.7	317.0	469.2	272.8
Small Community & Rural Development:												
FmHA												
c/	$ TOTAL	15,100,245.6	14,897,936.8	8,762,059.0	7,023,076.9	7,348,066.3	8,460,599.3	6,107,621.3	4,890,913.9	4,164,155.2	6,434,615.1	3,586,298.8
c/	FTE TOTAL	11,342	11,910	10,843	11,194	12,301	12,118	12,133	12,289	12,235	12,675	12,675
	$ TOTAL/FTE TOTAL	1,331.4	1,250.9	808.1	627.4	597.4	698.2	503.4	398.0	340.3	507.7	282.9

** NOTE: FOOTNOTES FOR TABLES 1-8 FOLLOW TABLE 8.

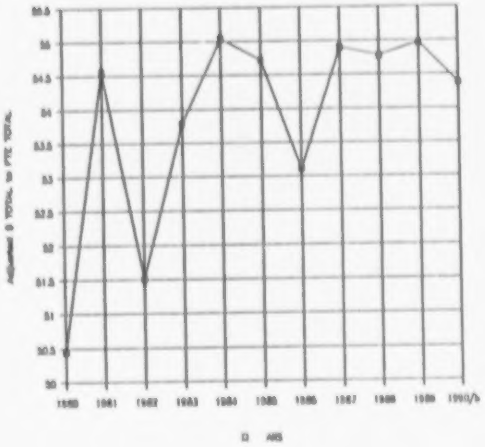
TABLE 7 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

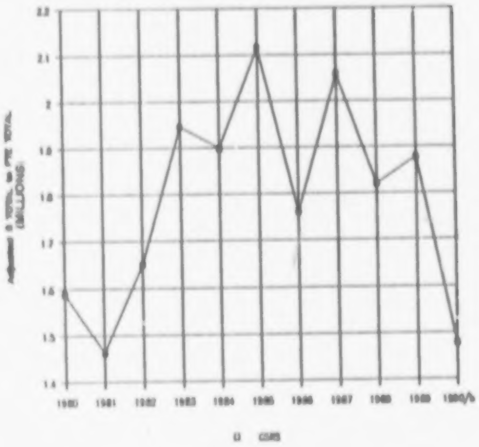
Relationship of Adjusted Total Funding to Total Personnel for Agencies

1980-1990

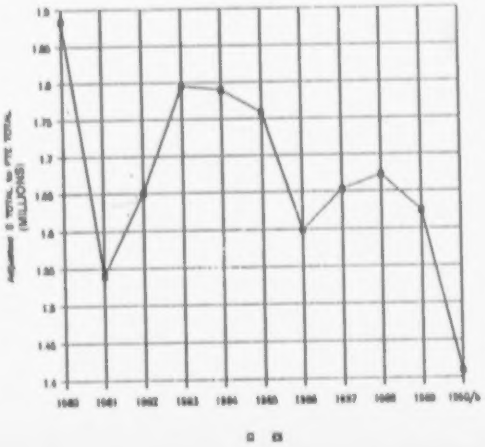
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

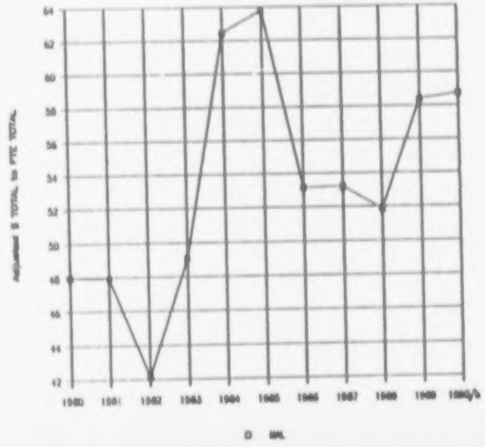


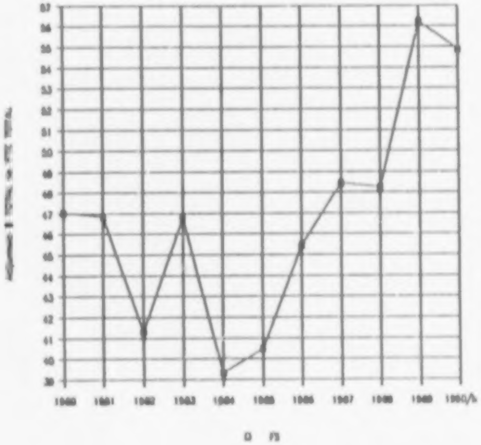
TABLE 7 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

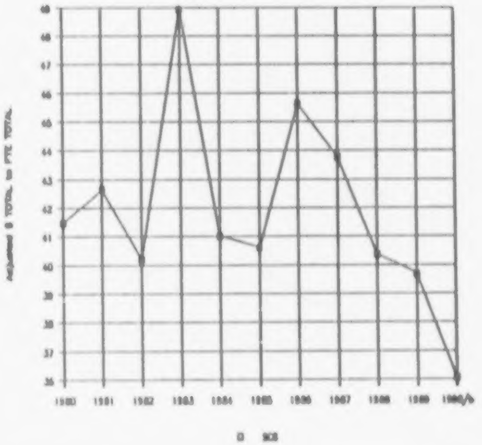
Relationship of Adjusted Total Funding to Total Personnel for Agencies

1980–1990

FOREST SERVICE



SOIL CONSERVATION SERVICE



ANIMAL/PLANT HEALTH INSPECTION SERVICE

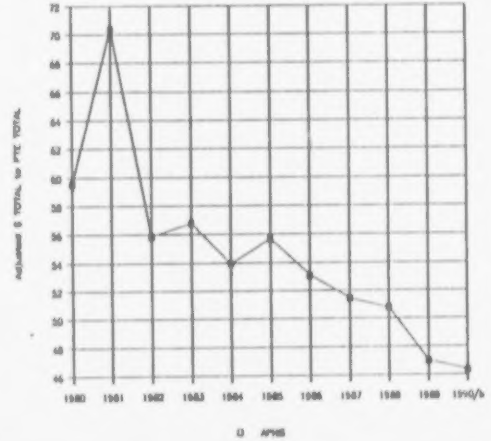


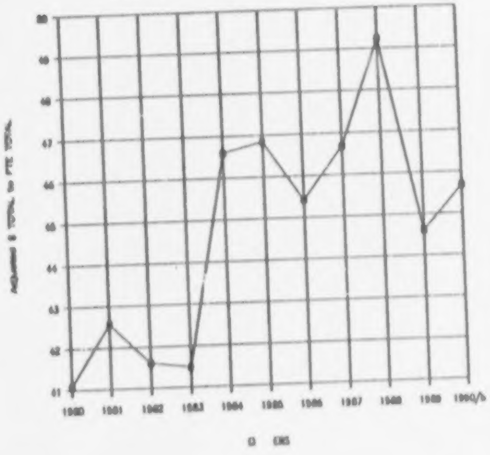
TABLE 7 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

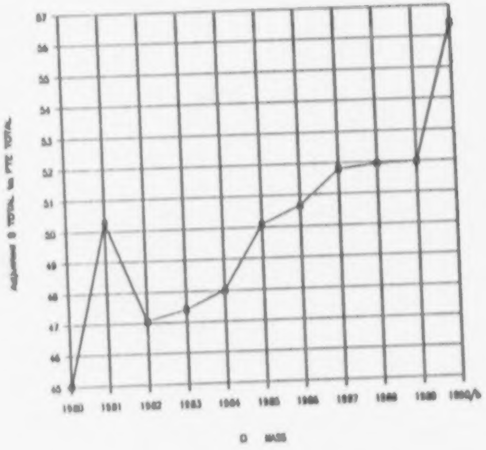
Relationship of Adjusted Total Funding to Total Personnel for Agencies

1980-1990

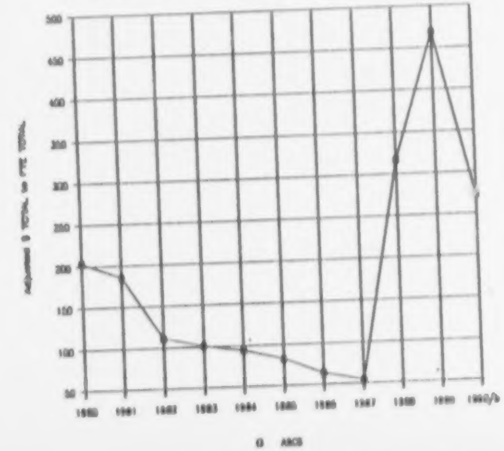
ECONOMIC RESEARCH SERVICE



NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE



FARMERS HOME ADMINISTRATION

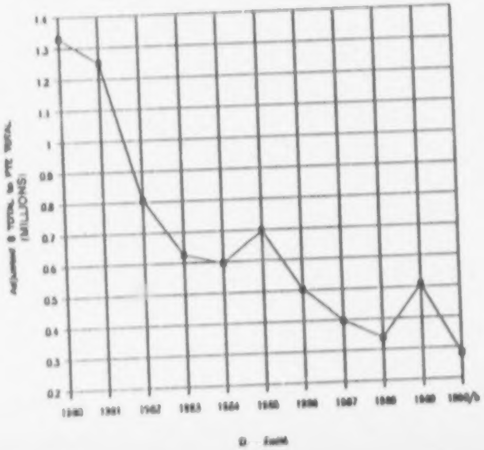


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TABLE 8 OF 8:

UNITED STATES DEPARTMENT OF AGRICULTURE
Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Agencies
1980-1990

WQ = Water Quality $ = Appropriated Funds   FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990/b
Science & Education:											
ARS											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	2.0	1.8	1.7	1.8	1.4	1.4	1.4	1.3	1.3	1.2	1.4
CSRS											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	4.8	4.9	4.5	3.9	3.9	3.5	3.9	3.3	3.7	4.1	6.0
ES											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL								2.5	2.4	2.6	3.8
NAL											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
Natural Resources & Environment:											
FS											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.9	0.8	0.9	0.9	1.1	1.1	0.9	0.9	1.1	1.1	0.9
SCS											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.5	0.4	0.5	0.5	0.4	0.4	0.6	0.8	0.8	1.1	1.3
Marketing & Inspection Services:											
APHIS											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	1.1	1.2	1.0
Economics:											
ERS											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL					1.4	1.4	1.5	1.4	1.3	1.4	4.9
NASS											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
International Affairs & Commodity Programs:											
ASCS											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL											
Small Community & Rural Development:											
FmHA											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL			1.2	2.1	1.1	1.0	1.7	2.0	2.7	1.9	2.5

** NOTE: FOOTNOTES FOR TABLES 1-8 FOLLOW TABLE 8.

# Because the numerator or denominator of the intended numerical ratio is unknown, no numerical relationship can be demonstrated in the empty cells.

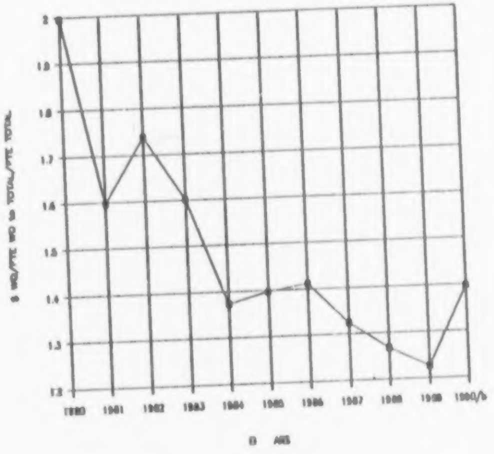
TABLE 8 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

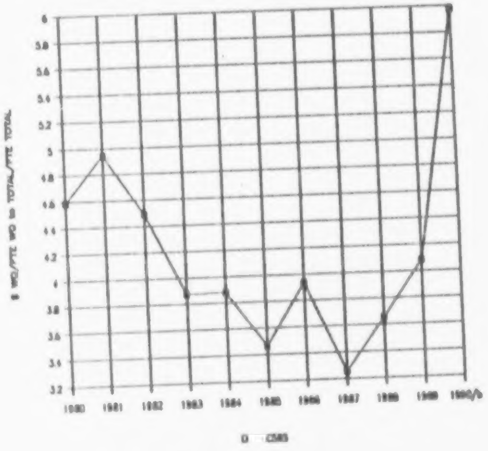
Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Agencies

1980-1990

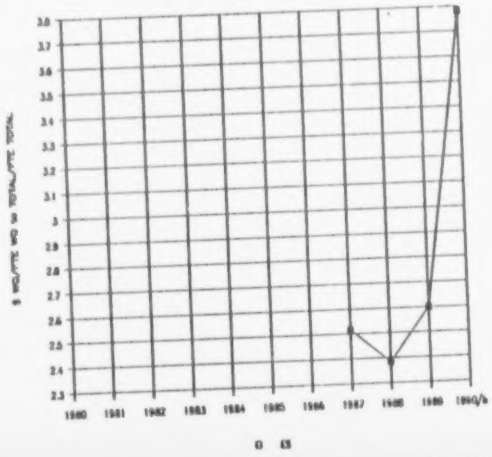
AGRICULTURAL RESEARCH SERVICE



COOPERATIVE STATE RESEARCH SERVICE



EXTENSION SERVICE



NATIONAL AGRICULTURAL LIBRARY

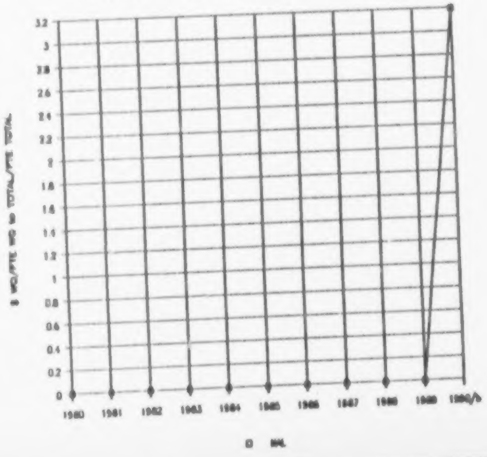


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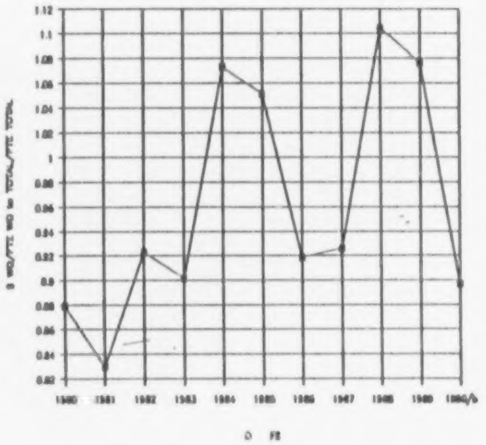
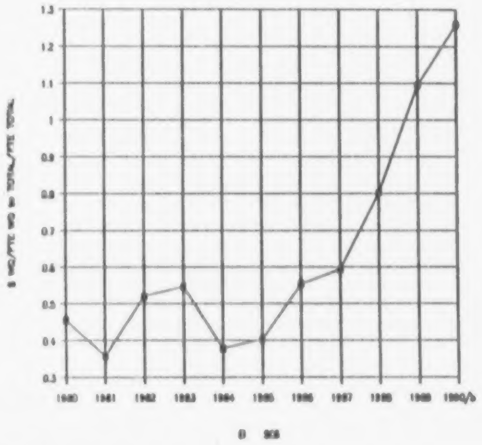
TABLE 8 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Agencies

1980-1990


FOREST SERVICE


SOIL CONSERVATION SERVICE

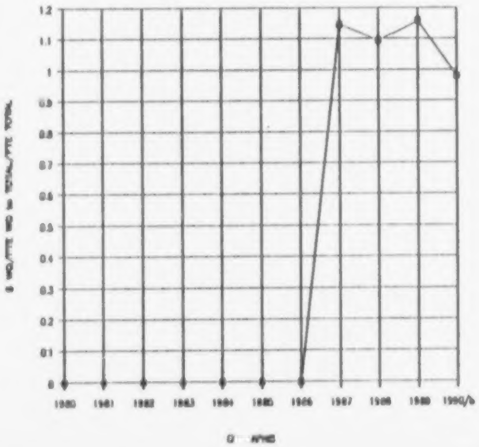

ANIMAL/PLANT HEALTH INSPECTION SERVICE

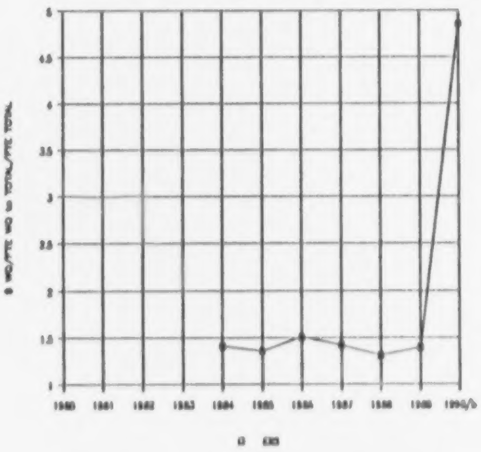
TABLE 8 GRAPHS:

UNITED STATES DEPARTMENT OF AGRICULTURE

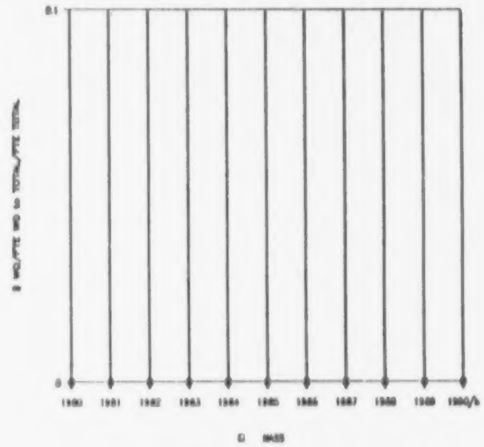
Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Agencies

1980–1990

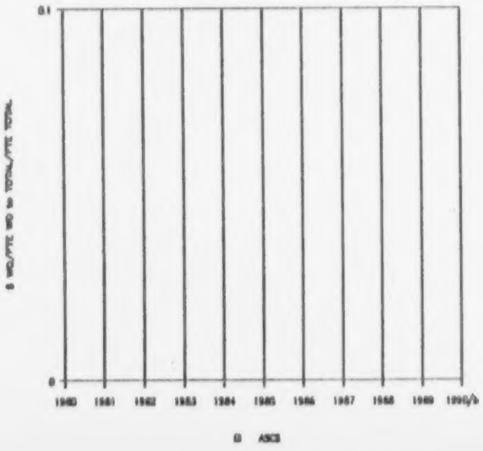
ECONOMIC RESEARCH SERVICE



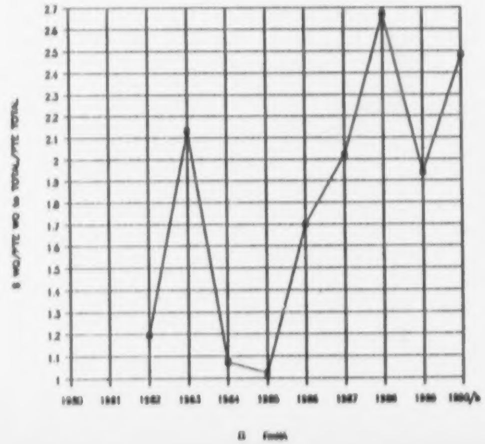
NATIONAL AG STATISTICS SERVICE



AG STABILIZATION & CONSERVATION SERVICE



FARMERS HOME ADMINISTRATION



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FOOTNOTES

UNITED STATES DEPARTMENT OF AGRICULTURE TABLES 1–8:

* $ WQ figures, WQ FTE's, and FTE TOTALS for the decade provided by the following budgetary officers of the USDA: Mrs. Mernie Braden, Supervisory Analyst, ARS; Mr. John Neesen, Branch Chief, Program Analysis Branch, APHIS; Mr. David J. Howe, Director of Program Support, FmHA; Mrs. Betty Lou Gilliland, Budget Officer, CSRS; Mr. Chuck Graves, Chief of Budget Branch, ES; Mr. Paul Bennett, Budget Officer, NAL; Mr. David Post, Program Analyst, SCS; Mr. Charles E. Caudill, Administrator, NASS; Mrs. Mikki Arias, Budget Analyst, ASCS; Ms. Betty Kellogg, Branch Chief, Administrative Expenses Branch, ASCS; Mr. Jerry Rockett, Branch Chief, Budget Presentation and Schedules, FS; Dr. John Miranowski, Director, Resources and Technology Division, ERS.

** The sources for $ TOTALS of the agencies are the United States Department of Agriculture's 1990 Special Budgetary Tables, Table 4, pages 22–29; and the President's Budgetary Apprendices (Index Years).

*** Note: FTE's for all agencies represent direct appropriations (figures do not include FTE's for reimbursable funds).

a/ CSRS has two Federal FTE's associated with water quality funding. Additionally, CSRS funds support extramural research, approximately 90 scientist–years, at the colleges and universities. Moreover, colleges and universities receive non–Federal funding for water quality research; based on the most recent data available, colleges and universities received $73 million (414 scientist–years) in 1986 and $86 million (475 scientist–years) in 1987.

b/ 1990 $ TOTALS are the President's Fiscal 1990 Budget Request.

c/ FmHA WQ FTE's for 1980 and 1981 are not available by individual programs. The $ WQ figures are obligations for fiscal years, 1980–1988; 1989 and 1990 $ TOTALS are budgetary estimates not obligations. FmHA does not conduct research, technology transfer, public information, nor educational activities related to water quality. FmHA does, however, operate several significant loan and grant programs designed to positively affect the quality, conservation, and use of water on farms and in rural communities. Source: Mr. Michael Wilkinson, Deputy Administrator, Program Operations, FmHA. The $ WQ figures are loans for Resource Conservation and Development; Soil and Water; Water and Waste Disposal Systems for Rural Communities; and Watershed Protection and Flood Prevention.

d/ Prior to 1987, APHIS had no water–quality initiative identified in its ongoing programs. For 1987 and thereafter, APHIS identified ongoing programs that contribute to the reduction of pesticide use; these programs do not represent water–quality projects.

e/ The $ WQ and FTE WQ figures for the Extension Service prior to 1986 cannot be identified. The 3 FTE's for fiscal years 1986–1990 are Federal Staff Years; at the State Level, there are 490 FTE's for water quality. Source: Mr. Chuck Graves, Chief of Budget Branch, ES.

f/ National Agricultural Library had no water quality program funding or water quality FTE's prior to 1990. Source: Mr. Paul Bennet, Budget Officer, NAL.

g/ National Agricultural Statistical Service's appropriations provide funding for two programs: Crop Livestock Estimates Program, and Statistical Research Program. NASS has never received direct funding for water quality programs; however, NASS receives water quality funds on a transferable basis from ERS's appropriated funds. In 1990, $1.5 million will be transferred from ERS's appropriated budget to NASS for pesticide use data surveys. Source: Mr. Charles E. Caudill, Administrator, NASS.

h/ Significant increases in water quality personnel in 1984 and 1988 are due to SCS's increased role in implementation of water quality legislation. (Clean Water Act, 1984; and Water Quality Act, 1987). Source: Mr. David Post, Program Analyst, SCS.

i/ ASCS water quality funding includes $50 million, in FY 1980, and $20 million, in FY 1981 for the experimental Rural Clean Water Program, which fully funded 21 long–term projects, that are still ongoing in 1989. ASCS water quality FTE's are unidentifiable for the decade, 1980–1990. Source: Mr. David Hall, Budget Director, ASCS. $ TOTALS do not include moneys tranferred from CCC's appropriated funds to ASCS for salaries and expenses. The substantial increase in funding in 1988 was to implement the Conservation Reserve Program.

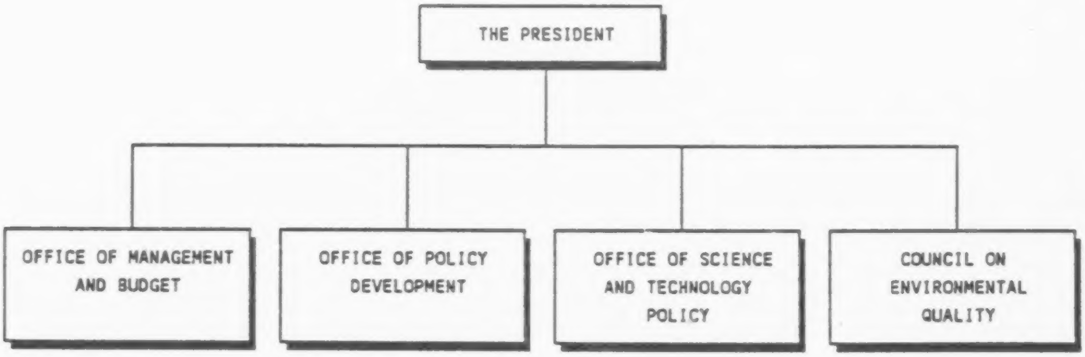
i/* ASCS: The FTE federal staff years shown relate to both ASCS appropriated and CCC Program Workload. Therefore, no relationship exists between the appropriated funds shown in the table and the ASCS Staff Year Equivalents. Source: Mr. David Hall, Budget Director, ASCS.

j/ ERS WQ $ figures, and WQ FTE's are unavailable prior to 1984. Source: Dr. John Miranowski, Director, Resources and Technology Division, ERS.

APPENDIX H: EXECUTIVE OFFICE OF THE PRESIDENT

Periodically reorganized and redefined to meet the goals of each administration, the Executive Office's present structure consists of the President, the Office of the Vice President, the White House Office, and eight agencies.[44] Of those eight, four agencies are involved in Federal water-quality policy development, coordination, and implementation: the Office of Policy Development, the Office of Science and Technology, the Office of Management and Budget, and the Council on Environmental Quality (Figure 13).

Figure 13:


THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
OFFICE OF POLICY DEVELOPMENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
COUNCIL ON ENVIRONMENTAL QUALITY

Office of Policy Development (OPD)

By Reorganization Plan Number 1 (1977) and later by Executive Order 12045 (1978), the Office of Policy Development was originally designated the Domestic Policy Staff (DPS); its name was summarily changed from DPS to OPD in the 1983 Appropriations Act.[48]

Created for the purpose of assisting the President in the development and coordination of long-range national policy, OPD acts as an arbitrator, working with the Federal agencies at the Assistant Secretary level and formulating policy in any of the following areas: domestic and international economics; the environment; energy; natural resources; or health and human services.

Environmental policy development is the responsibility of the Associate Director for Environment, Energy, and Natural Resources Policy. Sources influencing environmental-policy development are the Congress, the Federal Agencies, and the OPD staff. If significant disagreement exists between various factions, then a Presidential options paper is prepared by the OPD staff. The may respond by issuing a Presidential Directive in any of the following forms: Executive Order, Proclamation, or a Presidential Memoranda.[52]

Office of Science and Technology Policy (OSTP)

The Office of Science and Technology Policy was created in 1976 (P. L. 94-282) to replace the Office of Science and Technology. Since then, OSTP has been under intense scrutiny and heavy criticism about its inability to meet its mandates; hence, the Office of Science and Technology Policy has lost many of its functions.

Originally vested with the responsibility of developing a Five-Year-Outlook Report, OSTP's role was to be the long-range planner for Federal science and technology policy. According to a General Accounting Office Study, the Report tended to trail behind rather than predict new emerging science and technology issues; consequently, the responsibility of producing a Five-Year-Outlook Report was transferred to the Director of the National Science Foundation (NSF). (Note: NSF has replaced the Five-Year-Outlook Report with a " Science Indicators Report.")[29] An assessment of OSTP's ability to lead in the development of science and technology policy was prepared by the Congressional Research Service (CRS) in February, 1988. Entitled an Analysis of the Office of Science and Technology Policy, the report touches on many issues relevant to both environmental policy and, in particular, national water-quality policy as addressed within a national science and technology agenda. Listed below are the issues the report addressed:[30]

1. Can the anticipatory policy responsibilities given to OSTP, by statute, to respond to science and technology issues identified, researched, and developed by the Federal Agencies and subsequently, prioritized by the National Academy of Sciences be properly addressed, if this executive office feels the need to respond to the President's personal initiatives first and foremost?

   Prior to the Reagan Administration, OSTP was thought to be a channel directly into the White House, allowing the Federal Agencies access to, and ultimately control over national science- and technology-policy formulation, and prioritization. Since then, each presidential appointment for Director of OSTP has, instead, been a conduit to the Federal agencies on Presidential policy regarding science and technology. Both former directors, Dr.'s Keyworth and Graham--whose career training was in military research and physical science, respectively--implemented national policy in these "chosen presidential initiative areas" at the expense of the social and biological sciences.

2. Furthermore, the CRS report points out that the Director is authorized by Section 204 of P.L. 94-282 "to advise the President and work with the OMB in developing both research/development and science/technology budgets."[30]

The Director of OSTP also chairs the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). Established by P.L. 94-282, FCCSET's purpose is to address comprehensive science and technology issues affecting many federal agencies and thus, requiring a multi-lateral, coordinated response.[48] In 1987, probably in reflex to public criticism and in reaction to public concern over water quality, the following two FCCSET committees were created: the Committee on Life Sciences (CLS), and the Committee on Earth Science (CES). A recent FCCSET report, The Role of Science and Technology in the Management of the Nation's Ground-Water Resources (June, 1989) identifies many new research priorities essential to a national ground-water-protection strategy. It is yet unknown how the new director, Dr. D. Allan Bromley, whose career training is in nuclear physics,[5] will exercise his budgetary prerogatives in response to this document.

Federal Ground-Water Science and Technology Programs: The Role of Science and Technology in the Management of the Nation's Ground-Water Resources. Prepared by the Subcommittee on Ground Water, Committee on Earth Sciences of the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET), this Report is a comprehensive assessment of all federal players in both point-source- and nonpoint-source-contamination prevention. Made public in June 1989, this Report summarily reviewed the importance of ground water; the historical significance of and developments in ground-water research; as well as current federal agency programs, interagency coordination, and emerging federal issues relevant to national ground-water resources.[59]

Current federal ground-water programs primarily focus on assessment; research and technology development; education and training program development; and information management. As a result, future research needs--applying to both point-source and nonpoint-source contamination prevention, remediation, and mitigation--have been identified by USGS, USEPA, and USDA. Potentially invaluable as tools for the decision-making process to address emerging ground-water issues are the following research priorities[59] (Note: No attempt to prioritize this list was made.):

USGS

1. Coupled fluid flow and chemical reactions in ground water.
2. Development of new approaches and analyses of organic contaminants in water and sediment.
3. Fate and transport of immiscible contaminants in ground water.
4. The role of ground water in geologic processes.

USGS and EPA

5. Areal characterization of ground-water quality as affected by karst terrain.

EPA

6. Water quality monitoring, aquifer reclamation and source control.
7. Wetlands research and monitoring.
8. Biotic and abiotic degradation research on ground-water contaminants.

USDA

9. The origin and processes of contamination.
10. Development of methods for detection of contamination.
11. Development of prediction models.
12. Development of decision aids for agricultural producers, managers, and advisors.

13. The physical, chemical, and biological processes--as determined by climate, soil and crop type--on the fate, transport, and degradation of environmentally introduced agricultural wastes, amendments, and pesticides.
14. Research in genetically engineered biological organisms for contaminant degradation.
15. Development of water treatment devices for point of use (i.e., individual household).
16. Research on the economic, social, political, and health consequences of contaminants in both public and private water supplies.
17. Enhanced technology transfer to the rural community of new research developments--through educational and technical assistance--at both the State and Federal level.

Office of Management and Budget (OMB)

In 1970, the Office of Management and Budget was established within the Executive Office by Reorganization Plan Number 2. Further restructuring transferred many Presidential responsibilities to the new Director of OMB. From the past to the present, OMB's Executive responsibilities have evolved to include the following:[44]

1. Assisting the President in his program development and overseeing the Federal agencies to ensure intended results.

2. Developing coordinating mechanisms for maximum interagency cooperation and productivity. (i.e., formation of a task force.)

3. Assisting the President in the establishment of fiscal goals and in the preparation of the annual Presidential Budget Request.

4. Providing oversight and control of the administration of the budget.

5. Providing review of departmental recommendations for proposed legislation and advice on best option.

6. Assisting in the formulation and promulgation of Executive Orders to assure a prudent Federal response.

7. Providing the President quality and productivity evaluations, and progress reports on the Federal activities through the development and maintenance of various data-base systems.

The Federal Advisory Committee Act (5 U.S.C. App.) grants OMB the authority to form interagency task forces to facilitate efficient coordination and productive cooperation among the federal agencies. When the formation of a task force is requisite, an invaluable coordinating mechanism would be the "Interagency Communication Matrix." Originally conceived by Dr.'s Stephen Ragone, USGS and Terry Nipp, National Association of State Universities and Land Grant Colleges (NASULGC), ICM is being implemented to improve coordination for the Mid-Continent Herbicide Initiative (Figure 14). Yet, ICM can be applied to any interagency agenda--it allows for the quick identification of data-collection gaps and overlaps.

Additionally, at the request of the Chairman of the Interagency Task Force on Ground Water (OMB), a report entitled A Description of Major Federal Scientific and Technical Ground-Water Programs was prepared by the Department of Interior.[27] Circulated in February 1988, this Report is a compendium (chapters 4 and 5) of the FCCSET report previously reviewed.

Figure 14:

AGRICULTURAL CHEMICALS AND WATER QUALITY - RESEARCH MATRIX

	DEPARTMENT OF AGRICULTURE						GEOLOGICAL SURVEY			ENV. PROT. AGEN.	STATE INSTITUTIONS			OTHER
	ARS	CSRS SAES	ERS	FS	SCS	ES CES	WRD	GD	NMD		NAT. RES.	RES-EAR.	OTHER	
FARMING SYSTEMS EVALUATION														
Farming systems management														
Technology evaluation														
Effects on soils														
Socioeconomic consequences														
DEVELOPMENT OF SYSTEMS														
Management systems														
Chemical application														
Diagnostic tools														
FUNDAMENTAL PROCESS RESEARCH														
Water and solute transport														
Transformation Processes														
Sorption processes														
Biological Processes														
DEVELOP DECISION AIDS														
Targeting decision aids														
Evaluate and develop models														
Economic decision aids														
SPATIAL DATA														
Compile, integrate and transfer														
Evaluate														
CHEMICAL IMPACT ON ECOSYSTEMS														
Surface water														
Terrestrial														
SERVICE AND INFORMATION EXCHANGE														
Methods and technology development														
Transfer results to ET&A agencies														

Source: Dr. T. Nipp, Director of Water Quality Initiative
National Association of State Universities
and Land-Grant Colleges
Washington, D. C.

Council on Environmental Quality (CEQ)

The Council on Environmental Quality was established in 1970 by the National Environmental Policy Act (NEPA). CEQ consists of three presidentially appointed and senatorially confirmed members. Through the auspices of a Chairman and the aid of a small support staff, CEQ assists the federal agencies in the implementation of NEPA. Additionally, the Chairman is responsible for advising the President on all environmental matters and preparing the President's annual Environmental Quality Report.[16]

CEQ's Executive responsibilities lie in three environmental program areas: Environmental Policy Analysis and Development, Interagency Coordination of Environmental Quality Programs, and Environmental Data Acquisition and Assessment.

Environmental Policy Analysis and Development

Within the Environmental Policy Analysis and Development Program, the Council aids the President and his advisors in the development of national and international environmental policy. Additionally, this program prepares the President's annual Environmental Quality Report, encompassing all federal and private activities potentially affecting environmental quality, is prepared.

Interagency Coordination of Environmental Quality Programs

Interagency Coordination of Environmental Quality Programs is a CEQ program activity involving the effectuation of NEPA. As a consequence, program responsibilities include the following: interpretation and dissemination of the NEPA provisions; active participation in review of proposed legislation potentially affecting environmental quality; resolution of interagency disputes through the NEPA referral process; and assistance in environmental policy development involving more than one agency.

Environmental Data Acquisition and Assessment Program

Within the Environmental Data Acquisition and Assessment Program, CEQ tracks the environmental research and monitoring programs of the federal agencies.[72] The end result is CEQ's Environmental Trends Sourcebook, a periodic publication, containing an up-to-date assimilation of Federal environmental data.

Environmental Quality. Focusing on selected environmental conditions that are largely "manmade," this Report includes chapters on municipal solid waste; urban air quality; defense lands and installations; and developed water resources.

Within the developed water resources chapter, the Report identifies **ground water** as an old issue needing resolution. Additionally, the Report points out that the 100th Congress proposed (though did not enact) legislation to accomplish the following:[17]

1. Formulation of community educational programs on protection of ground-water resources.
2. Collection and assimilation of scientific data encompassing ground-water quantity, quality, and hydrogeology.
3. Development of technologies to control point-source and nonpoint-source contamination.
4. Development of information-management programs to provide prevention and remediation.
5. Development of a federal, state, and private cost-sharing program.
6. Identification of knowledge gaps.

Furthermore, CEQ's Report quantifies the nonpoint contamination problems in tables 2-7d, 2-7e, 2-10, and 4-5e, Environmental Trends (Figures 15 and 16).

Figure 15:

Table 2-7e.
Surface waters impacted by nonpoint sources, 1985

Status	Rivers (thousands of miles)	Lakes (millions of acres)	Estuaries (thousands of square miles)	Ocean (thousands of shore-line miles)
No use impairment	230	7.20	11.1	6.30
Threatened	48	3.70	3.0	0.10
Moderately impaired	87	3.50	1.6	0.34
Severely impaired	30	0.88	0.8	0.01
Undistinguished	9	0.09	2.5	0.07
Total assessed waters	404	15.37	19.0	6.82

Source: The Association of State and Interstate Water Pollution Control Administrators, in cooperation with the U.S. Environmental Protection Agency. 1985. America's clean water: The states' nonpoint source assessment, 1985. Washington, D.C.

Note: Does not include data for Alaska. States report there are 1.48 million river miles, 26.6 million lake acres, 32,000 estuary square miles and 23,000 ocean coastline miles.

Table 2-7d.
Nonpoint source contributions to receiving waters by source (millions of tons), 1980

Source	TSS	BOD	Nitrogen	Phosphorus
Cropland	1870.00	9.00	4.30	1.56
Pasture and rangeland	1220.00	5.00	2.50	1.08
Forest land	256.00	0.80	0.39	0.09
Construction sites	197	NA	NA	NA
Mining sites	59	NA	NA	NA
Urban runoff	20	0.5	0.15	0.019
Rural roadways	2	0.004	0.0005	0.001
Small feedlots	2	0.05	0.17	0.032
Landfills	NA	0.3	0.026	NA
Background	1260.00	5.00	2.50	1.10
Total	4886.00	20.65	10.04	3.88

Source: Adopted from Bailey, G.W. & T.E. Waddell. 1979. Best management practices from agriculture and silvaculture: an integrated review, p. 37. IN: Best management practices for agriculture and silvaculture. Ann Arbor Science, Ann Arbor, MI.

Note: TSS=total suspended solids. BOD=biochemical oxygen demand. Excluded from the survey area are 207 million acres of public lands (14% of the contiguous United States), mostly in the Rocky Mountains, because of inadequacy of information. Urban runoff includes separate storm sewers only.

Figure 16:

Table 2-10.
Detection of pesticides in stream and river water and sediment (average number of detections per 100 samples), 1975-1980

Year	Organochlorine insecticides		Organophosphate insecticides	
	In sediment	In water	In sediment	In water
1975	65.3	2.4	NA	2
1976	82.3	2.9	NA	5
1977	74.2	3.2	NA	7
1978	41.1	3.1	NA	5
1979	52.1	1.2	NA	4
1980	NA	0.9	NA	6

Source: Gilliom, R.J., R.B. Alexander & R.A. Smith. 1985. Pesticides in the Nation's rivers, 1975-1980, and implications for future monitoring, fig. 3, p. 12 & fig. 6, p. 19. U.S. Department of the Interior, Geological Survey Water-Supply Paper 2271. Reston, VA.

Table 4-5e.
Pesticide use (million pounds of active ingredients), 1964-1987

Year	Herbicides	Insecticides	Other	Total
1964	76	143	72	291
1966	112	138	78	328
1971	207	127	130	464
1976	374	130	146	650
1982	451	71	30	552
1986	410	59	6	475
1987	365	57	7	429

Source: 1964: U.S. Department of Agriculture, Economic Research Service. 1968. Quantities of pesticides used by farmers in 1964, pp. 19-27. AR-131. Washington, D.C.

1968: U.S. Department of Agriculture, Economic Research Service. 1970. Quantities of pesticides used by farmers in 1968, pp.22-23. AR-179. Washington, D.C.

1971: U.S. Department of Agriculture, Economic Research Service. 1977. Quantities of pesticides used by farmers in 1971, pp. 9-50. AR-252.Washington, D.C.

1976: U.S. Department of Agriculture, Economic Research Service. 1979. Quantities of pesticides used by farmers in 1976, pp. 9-52. AR-252. Washington, D.C.

1982: U.S. Department of Agriculture, Economic Research Service. 1983. Inputs situation and outlook report. IOS-2. Washington, D.C.

1986: U.S. Department of Agriculture, Economic Research Service. 1987. Inputs situation and outlook report, table 14, p. 16 (updated). AR-5. Washington, D.C.

1987: U.S. Department of Agriculture, Economic Research Service. 1988. Inputs, situation and outlook report, p. 16. AR-9. Washington, D.C.

Note: For the year 1964, 1966, 1972, and 1976, estimates of pesticide use are for total use on all crops and livestock in the United States. The 1982 estimates are for major field and forage crops only and represent 33 major producing states excluding California. The 1986 and 1987 estimates are for the 10 major field crops.

In conclusion, Building a Better America--the President's February 9, 1989 Address to the Nation--further clarifies the Executive position with the establishment of a Presidential Water-Quality Initiative. The fundamental principles established in the Initiative are the "protection of the Nation's ground-water resources from fertilizers and pesticides without jeopardizing the economic vitality of U.S. agriculture."[60] Suggesting farmers are the ultimate "stewards of water quality," the Initiative propounds that farm-production practices must be altered and that State and Federal resources provide the necessary educational and technical assistance.

To finance the Federal element, the President's 1990 Budget Request provides an additional $64 million to existing water quality programs in the Department of Agriculture, Commerce, Interior, and the Environmental Protection Agency. With this additional funding, these organizations are charged with developing and demonstrating nondegrading farming practices (USDA); monitoring the effects of agricultural run-off on coastal and inland waterways (NOAA); monitoring surface and ground-water quality (USGS); and developing a coordinated Federal-State farmer educational program (EPA).[60]

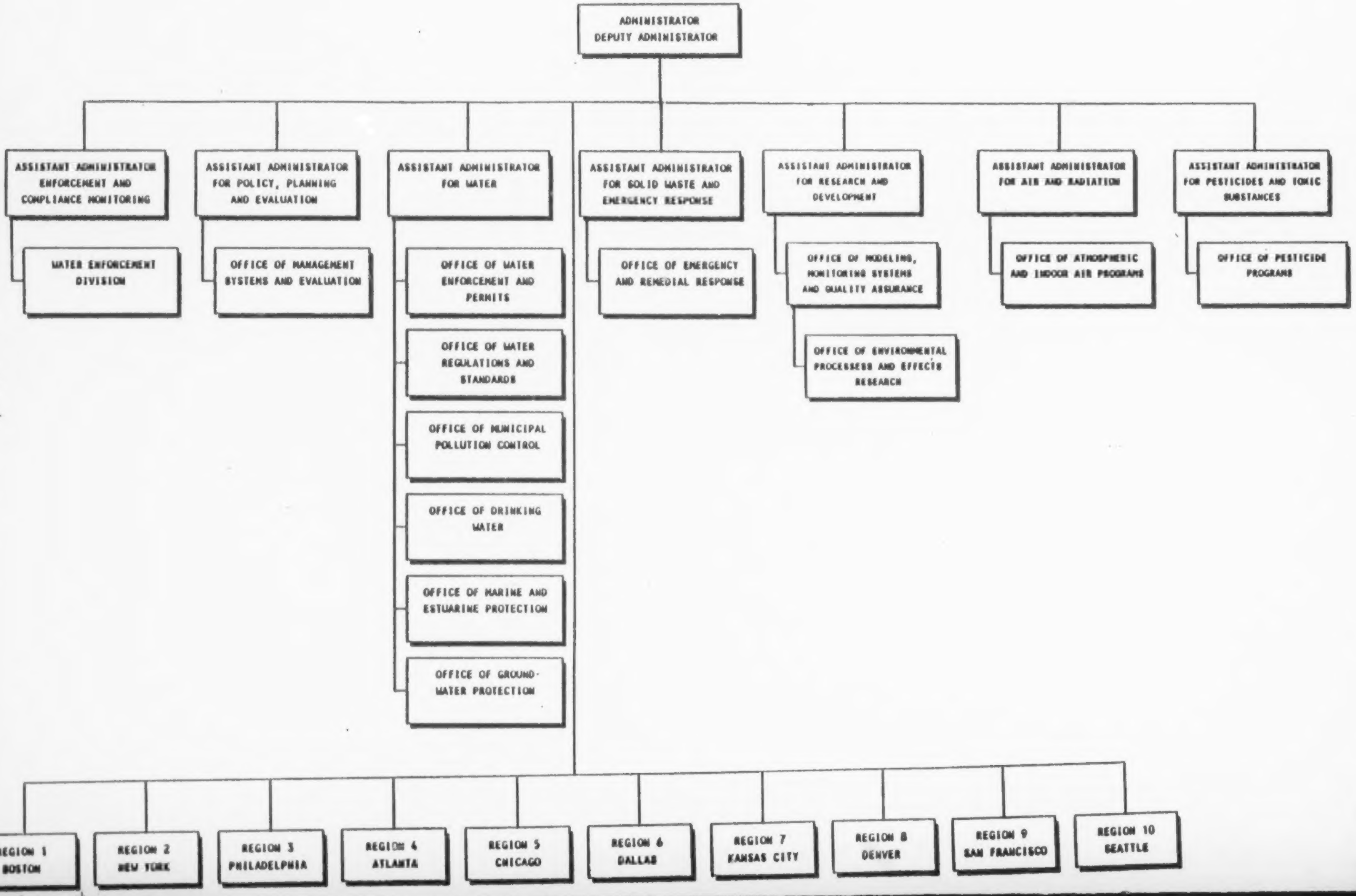
APPENDIX F: UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Established in 1970, the Environmental Protection Agency is the Federal "watchdog" for the environment. As such, EPA--in cooperation with local governments, States, and other Federal agencies--strives to control pollution using environmental monitoring and research; standards setting; and enforcement.[44] As caretaker of the Nation's waters, the following Assistant Administratorships and Regional Offices are involved in water-quality activities (Figure 9). In response to a growing National concern about agri-chemical contamination of groundwater, the Environmental Protection Agency has formulated--though not released--the Agricultural Chemicals in Groundwater Strategy.

EPA Water-Quality Tables

Because funding is allocated by medium, EPA's water-quality dollars are easily identifiable. However, prevention, remediation, and mitigation of agri-chemical ground-water contamination is a cross-media issue. Hence, water-quality--as this document defines it--not only involves water-quality funding but also elements of drinking water, and pesticides. Consequently, Underground Injection Control Funds, Pesticide Survey Funds, and Groundwater Protection Program Funds were added to EPA's identified water-quality media dollars for participating Administratorships and Regional Offices.

Figure 9: U. S. ENVIRONMENTAL PROTECTION AGENCY WATER QUALITY ORGANIZATIONAL CHART


ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSISTANT ADMINISTRATOR ENFORCEMENT AND COMPLIANCE MONITORING
WATER ENFORCEMENT DIVISION
ASSISTANT ADMINISTRATOR FOR POLICY, PLANNING AND EVALUATION
OFFICE OF MANAGEMENT SYSTEMS AND EVALUATION
ASSISTANT ADMINISTRATOR FOR WATER
OFFICE OF WATER ENFORCEMENT AND PERMITS
OFFICE OF WATER REGULATIONS AND STANDARDS
OFFICE OF MUNICIPAL POLLUTION CONTROL
OFFICE OF DRINKING WATER
OFFICE OF MARINE AND ESTUARINE PROTECTION
OFFICE OF GROUND-WATER PROTECTION
ASSISTANT ADMINISTRATOR FOR SOLID WASTE AND EMERGENCY RESPONSE
OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
ASSISTANT ADMINISTRATOR FOR RESEARCH AND DEVELOPMENT
OFFICE OF MODELING, MONITORING SYSTEMS AND QUALITY ASSURANCE
OFFICE OF ENVIRONMENTAL PROCESSES AND EFFECTS RESEARCH
ASSISTANT ADMINISTRATOR FOR AIR AND RADIATION
OFFICE OF ATMOSPHERIC AND INDOOR AIR PROGRAMS
ASSISTANT ADMINISTRATOR FOR PESTICIDES AND TOXIC SUBSTANCES
OFFICE OF PESTICIDE PROGRAMS
REGION 1 BOSTON
REGION 2 NEW YORK
REGION 3 PHILADELPHIA
REGION 4 ATLANTA
REGION 5 CHICAGO
REGION 6 DALLAS
REGION 7 KANSAS CITY
REGION 8 DENVER
REGION 9 SAN FRANCISCO
REGION 10 SEATTLE

Assistant Administrator for Enforcement and Compliance Monitoring (OECM)

Office of Enforcement and Compliance Monitoring

The Office of Enforcement and Compliance Monitoring reviews EPA policies and strategies in all media to insure--once that policy is issued--it is implementable and enforceable. Groundwater issues are reviewed by OECM's Water Enforcement Division. Additionally, the Pesticides and Toxic Substances Division of OECM has been reviewing (focusing on enforceability) the Agricultural Chemicals in Groundwater Strategy.[56]

OECM Tables. OECM has received no direct allocations for water-quality since 1982.

Assistant Administrator for Policy, Planning, and Evaluation (OPPE)

Office of Management Systems and Evaluation

Within OPPE, two branches of the Office of Management Systems and Evaluation are involved with groundwater issues; they are the Environmental Results Branch and the Accountability Systems Branch. In the Accountability Systems Branch, water analysts review the progress made by the Office of Water in promulgating rules, regulations, and reports on water quality. Additionally, this Branch maintains the automated Strategic Planning and Management System (SPMS) database. SPMS is used as a guide for EPA Headquarters when designing and implementing programs in water quality.[18]

> **OPPE Tables**. OPPE receives no appropriated monies in its base program for Water Quality. The Water Quality Funds in the years, 1985-1988, reflect reprogrammed dollars for Water Quality projects from the Office of Water. Officially OPPE has no FTE's appropriated in its base program for Water Quality.*

Assistant Administrator for Water (OW)

Six offices of the Assistant Administratorship for Water are involved in water-quality activities. Of those six offices, the Office of Water Regulations and Standards, the Office of Drinking Water, and the Office of Groundwater Protection are the most absorbed in agri-chemical/ground-water activities.

Office of Water Regulations and Standards

Since the enactment of the Federal Water Pollution Control Act (FWPCA) in 1972, the Office of Water Regulations and Standards (OWRS) has been involved in agricultural chemical/ground-water issues. Section 208 of FWPCA required the States and local water-management authorities to develop point- and nonpoint-source pollution management plans. Section 304 of FWPCA required the organizational predecessor of OSWR to develop and publish technical guidelines to aid the States and water authorities in fulfilling the requirements of Section 208. With the decline of funding for Section 208 in the early 1980's, OSWR focused its attention on and formulated the Nationwide Urban Runoff Program (NURP).

In 1987, following the enactment of Section 319 of the Clean Water Act, OSWR was directed to oversee nonpoint-source assessment and prevention programs being developed by the States. To date, OSWR still has a nonpoint-source program; however, with the establishment of an Office of Ground-Water Protection, the lead role in ground-water protection is played by this newly created office.[47]

OSWR has four divisions; they are Assessment and Watershed Protection; Industrial Technology; Criteria and Standards; and Analysis and Evaluation. As one of its many duties, the Assessment and Watershed Protection Division is responsible for managing a national program for nonpoint-source pollution. Recently, the Division completed the National Bioaccumulation Study of toxic pollutants (including pesticides) in fish flesh.[47]

Responsible for developing effluent-guideline regulations of all pollutant discharges, the Industrial Technology Division has domain over pesticide manufacture and formulation. On the other hand--the Criteria and Standards Division develops technical criteria on manufactured products that are pollutants (including pesticides) to protect human health and the environment. And the Analysis and Evaluation Division acts as the Agency's coordinator, and evaluator on each project's possible cost, impact, and feasibility.

Office of Drinking Water

Within the Office of Drinking Water, the Criteria and Standards Division has overall responsibility for development of drinking water standards for various contaminants (including nitrate and various pesticides). In order to provide a national assessment of pesticide contamination in ground water. the Office of Drinking Water has initiated a National Survey of Pesticides in Drinking Water.[14]

Office of Ground-Water Protection

Having the lead role in ground water, the Office of Ground-Water Protection (OGWP) oversees the implementation of the EPA's Ground Water Protection Strategy. Additionally, the Office of Ground-Water Protection serves as the internal coordinator for ground water policy within EPA.

With the enactment of the 1986 Safe Drinking Water Act, the Office of Ground-Water Protection implemented the Wellhead Protection Program; the Sole Source Aquifer Program; and the Sole Source Aquifer Demonstration Program. Overseeing the implementation of these programs at Headquarters are three operational staffs: the Technical and Regulatory Analysis Staff; Ground-Water Policy and Management Staff; and Source Assessment and Information Management Staff.

At the Regional level, the various Offices of Ground-Water Protection are the primary points of contact for EPA with the State agencies implementing ground-water protection programs. The Regional Offices provide technical support, and oversee State ground-water strategy grant funds. The Regions also coordinate ground-water data collected and enter the data in STORET (the EPA's ground-water database).[32]

OW Tables. The water-quality funding depicted in the tables represents the summation of OW's Water-Quality Media Funds; Underground Injection Control Funds; Pesticide Survey Funds, and Groundwater Protection Program Funds.

Assistant Administrator for Solid Waste and Emergency Response (OSWER)

Office of Emergency and Remedial Response

Authorized by Comprehensive Environmental Response, Compensation, and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986, the Office of Emergency and Remedial Response (Superfund) responds to emergency situations involving spills of hazardous substances (including agricultural chemicals) that pose a threat to human health and the environment.[40]

OSWER Tables. The water-quality funds OSWER receives (depicted in the tables) does not include Superfund media dollars.

Assistant Administrator for Research and Development (ORD)

Within the Office of the Assistant Administrator for Research and Development, the groundwater research program involving agricultural chemicals is carried out by two offices: the Office of Modeling, Monitoring Systems, and Quality Assurance; and the Office of Environmental Processes and Effects Research. Both offices are providing research and technical support to the Office of Pesticide Programs to meet the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requirements.[41]

Office of Modeling, Monitoring Systems, and Quality Assurance

The Office of Modeling, Monitoring Systems, and Quality Assurance is primarily involved with assessing methods and models at field scale to ensure that appropriate management practices have been implemented to prevent groundwater contamination by pesticides.

Office of Environmental Processes and Effects Research

The Office of Environmental Processes and Effects Research is involved with determining how pesticides contaminate groundwater. The Office characterizes the pesticide processes occurring in soils and ground water; investigates leaching factors; and studies microbial degradation of pesticides.

ORD Tables Research and Development's water-quality funding (depicted in the tables) depicts all aspects water-quality research occurring at 16 ORD laboratories. That portion of water-quality research solely involved with agricultural chemicals was not identifiable.

Assistant Administrator for Air and Radiation (OA&R)

Office of Atmospheric and Indoor Air Programs

Among its many concerns, Air and Radiation is involved with the abatement of pollution involving drift of sprayer-applied agri-chemicals.

OA&R Tables. With its Office of Atmospheric and Indoor Air Programs, OA&R is involved in water-quality activities. The Atmospheric Program received water quality funds in 1984 and 1985 involving acid deposition (acid rain).[39]

Assistant Administrator for Pesticides and Toxic Substances (OPTS)

Office of Pesticide Programs

The Office of Pesticide Programs (OPP) has responsibilities with pesticides in surface and ground water. Within OPP, the following office and divisions are involved with pesticide contamination prevention, mitigation, or remediation of ground water: Policy and Special Projects Office; Registration Division; Special Review and Reregistration Division; Environmental Fate and Effects Division; Field Operations Division, and Biological and Economic Analysis Division.

The Policy and Special Projects Office is revising Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy. The Strategy proposes the States have the lead role in pesticide management, and provides the framework for standards setting regarding maximum pesticide contamination levels.[28]

The Registration Division screens all new pesticides or proposed new outdoor uses of existing pesticides for ground-water contamination potential.[28] Special Review and Reregistration Division reviews existing pesticides and their uses to determine --based on new research technologies--the degree of environmental risk.

The Environmental Fate and Effects Division reviews pesticide registrations to determine if any additional ground and surface water data are needed from the registrants. Additionally this Division develops the guidelines to be used by the registrants in ground-water monitoring, and maintains a database on the monitoring results.

The Field Operations Division is EPA's pesticides in ground-water liaison to the States, EPA Regional Offices, and the public sector. As their name implies the Biological and Economic Analysis Division conducts analyses on pesticide use and benefits; validates and interprets technical data on pesticide use; and performs economic analyses on the quality and yield of regulatory programs regarding those chemicals of concern to ground water. Additionally, the Biological Analysis Branch is responsible information regarding best management practices and pesticide application techniques.[28]

> OPTS Tables. Only in 1984 and 1985 did OPTS receive direct allocations in water-quality funding. A portion of this funding is for coordination activities provided by OPP for the Office of Drinking Water's National Pesticide Survey.

Assistant Administrator for Resources Management (OARM)

As its name implies, the Assistant Administrator for Resources Management provides management services involving contracts and grants; human resources and their health benefits; office of the comptroller; informational systems; and buildings and facilities.

> OARM Tables. Data are no longer available on water quality funds received by OARM. The 1987 figure represents funds reprogrammed to OARM's National Computer Center by the Office of Water (OW). To support their environmental programs, OW purchased expanded Automated Data Processing capability.[45]

Assistant Administrator for External Affairs (OEA)

The Office of the Assistant Administrator for External Affairs recently was reorganized by Administrator Reiley into a new administratorship: Assistant Administrator for International Affairs.[53]

> OEA Tables. Between the years 1983-1986, OEA received water-quality funding for the administration of Environmental Impact Statements (EIS) involving wetlands protection. In 1986, wetlands protection became the domain of the Office of Wetlands Protection, a newly created office under the jurisdiction of the Assistant Administrator for Water.

EPA Regional Offices

Organizationally, the Environmental Protection Agency consists of ten Regional Offices and Headquarters (Washington, D.C.). Headquarters (reviewed above) and all ten Regional Offices are involved in water-quality activities. The ten Regions are the following: Boston (Region 1); New York (Region 2); Philadelphia (Region 3); Atlanta (Region 4); Chicago (Region 5); Dallas (Region 6); Kansas City (Region 7); Denver (Region 8); San Francisco (Region 9); and Seattle (Region 10).

> Regional Offices Tables. Water-quality funding--represented in the tables--for the Regional Offices is the summation of Regional allocations for the following purposes: Underground Injection Control Funds, Pesticide Survey Funds, Groundwater Protection Program Funds, and Water-Quality Media Funds.

Evolving Issues Involving EPA

Formation of a Bureau of Environmental Statistics

The Environmental Protection Agency is charged with collecting, analyzing, and disseminating information about environmental conditions and trends; yet environmental data collected and stored by the Environmental Protection Agency are without quality control, careful measurement protocols, or through analyses.

Hence, both internal and external forces are at work to rectify the situation. Internally, *Federal Statistics Agencies as Models for a Bureau of Environmental Statistics*, written by Dr. Wellington of the Statistical Policy Branch, is being circulated.

Of the many points the paper addresses, the following are the major ones:[70]

1. A Federal statistic agency called the Bureau of Environmental Statistics should be established within the EPA.
2. The mission of the Bureau should be broad in scope with its budget addressed as a separate line item to ensure the independent and nonpartisan treatment of politically sensitive environmental data.
3. To ensure credibility of its statistics, statutory safeguards should be made that are similar to those of the twelve existing Federal statistics agencies.
4. To ensure the Bureau's integrity of mission, the Bureau's program should be totally separate from the regulatory functions of the EPA.

Externally, Reforming Environmental Regulation: Three Modest Proposals by Paul Portney, Director of the Center for Risk Management at Resources for the Future (Washington, D.C.) propounds the same argument.[46]

Creation of a Department of Environmental Protection

In 1970, when the Environmental Protection Agency was first created, its organizational structure was designed to address the environment as a single system. Yet, environmental laws--such as air and water--focus on the environment as separate media. As a consequence, because laws and EPA's organizational structure no longer allow a system approach to the environment, cross-media pollutants are escaping control and regulation.[62]

Hence, three Bills are in Committees of the House and Senate proposing the establishment of a Cabinet-level Department of Environmental Protection. The Bills propose the following:[21,22,23]

1. A shift from media-specific concerns to a broader focus on releases to all media from the four types of sources: mobile sources, point sources, nonpoint sources, and substances.
2. A single permit system governing permissible releases of pollutants to all parts of the environment for major facilities.
3. No permit issued unless the applicant uses, to the maximum extent practical, available methods for reducing total releases to the environment.
4. Integrated grant assistance to the state and local governments to help deal with cross-media environmental problems.

5. And lastly, regardless of the source of the pollutant or the location into which it is discharged, only one primary standard: prevention of unreasonable risk

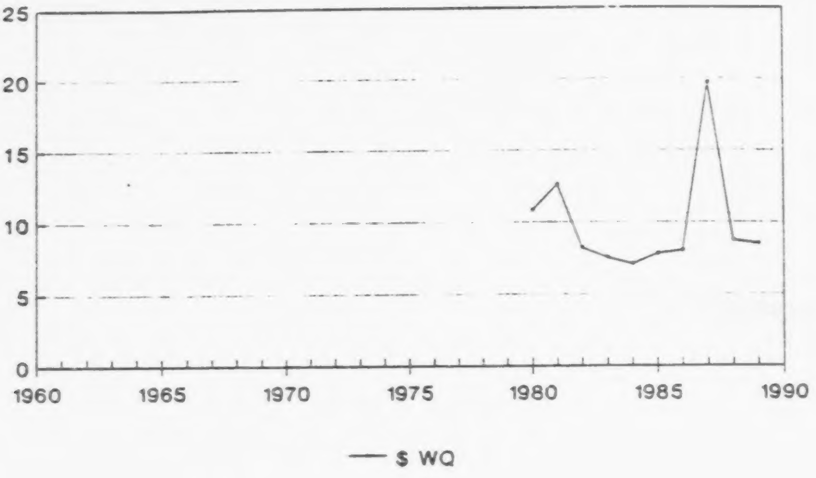
Prevention verses Remediation and Mitigation

The Environmental Protection Agency is charged to protect the environment through pollution prevention, remediation, and mitigation. However, over the years the EPA--instead of preventing--has been controlling pollutants and wastes. Another OTA report addressed this problem: From Pollution to Prevention (A Progress Report on Waste Reduction). This OTA report did not recommend regulatory means to swing the pendulum toward prevention; instead, the Report recommended the reduction of pollutants at their source.[43]

Regarding agri-chemical contamination of ground water--a nonpoint-source pollutant, a cross-media pollutant--EPA has no legal means to commit to prevention. Additionally, Section 107 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) allows EPA--once the parties responsible are determined--to hold those parties liable for the costs of clean-up. Yet, if EPA determines farmers responsible for ground-water contamination by agricultural chemicals, and determines education to be the most appropriate clean up and preventative measure, they are not allowed to charge the farmer for the education received.

In summary, Figure 10 demonstrates water-quality funding provided Kansas City (Region 7); whereas Figure 11 demonstrates

Figure 10: Water Quality Base Funding for Region 7
1980-1990
(Thousands of Dollars)



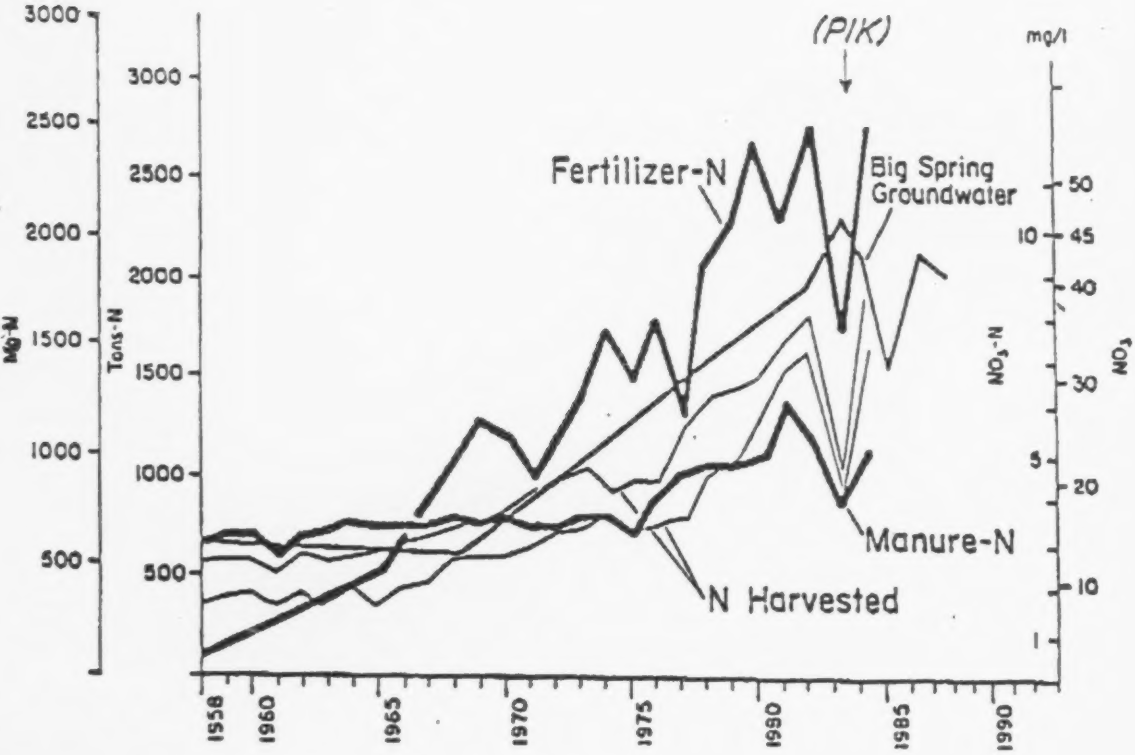


Figure 11:

Mass of fertilizer-N and manure-N applied in the Big Spring basin, annual average nitrate concentration (right for scale) in groundwater at Big Spring through WY-1987, and estimated mass of N harvested in corn grain from the basin (after Hallberg, 1987 et al., 1984).

long-term monitoring for nitrates in the ground water of Big Springs Basin, Iowa (in Region 7's territory). Even with substantial spending to enhance water quality in Region 7, the agri-chemical contaminant problem has intensified over time because EPA cannot successfully address the problem at its source (the farmer).

TABLE 1 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Water Quality Base Funding for Assistant Administrators

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
$ WQ	5,224.2	7,117.5	5,267.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	24,421.7	31,158.8	34,655.3	6,852.1	8,344.7	8,773.2	8,915.8	9,198.1	10,790.8	13,363.5	13,349.8
External Affairs (OEA)											
c/ $ WQ	0.0	0.0	0.0	651.1	707.4	947.5	495.5	0.0	0.0	0.0	0.0
$ TOTAL	0.0	0.0	0.0	13,407.6	13,904.9	14,004.6	13,823.2	10,545.1	10,993.2	11,247.9	12,381.0
Administration and Resources Management (OARM)											
d/ $ WQ	243.9	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
$ TOTAL	119,525.8	121,613.0	136,132.7	134,741.1	143,450.9	181,412.1	163,803.5	227,533.6	281,809.8	284,212.6	314,750.4
Pesticides and Toxic Substances (OPTS)											
$ WQ	0.0	0.0	0.0	0.0	520.0	524.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	96,798.2	106,465.1	81,128.7	77,120.7	83,096.7	94,217.8	138,724.1	152,080.1	151,524.3	204,833.6	149,443.0
Research and Development (ORD)											
$ WQ	64,049.7	61,440.1	44,030.9	30,814.3	26,245.1	27,956.8	23,513.5	25,478.2	24,451.4	24,085.3	26,306.5
$ TOTAL	335,001.0	347,371.9	271,087.8	226,513.0	247,137.0	301,709.4	314,103.1	343,324.6	355,452.8	385,436.7	421,479.9
Air and Radiation (OA&R)											
$ WQ	0.0	0.0	0.0	0.0	715.0	828.8	0.0	0.0	0.0	0.0	0.0
$ TOTAL	89,950.1	93,247.4	66,964.7	64,457.8	68,871.3	73,579.8	76,764.5	84,879.0	89,207.5	101,792.9	114,876.9
Water (OW)											
b/ $ WQ	79,690.0	82,305.1	55,385.3	70,287.9	78,247.4	65,437.6	75,760.6	84,795.2	70,681.7	104,893.5	106,768.1
$ TOTAL	126,229.2	125,510.9	58,773.1	72,758.8	80,522.4	81,951.1	95,739.1	114,255.1	98,514.1	133,836.2	138,189.6
Policy, Planning, and Evaluation (OPPE)											
e/ $ WQ	0.0	0.0	0.0	0.0	0.0	450.0	200.0	270.0	150.3	0.0	0.0
$ TOTAL	0.0	17,130.3	22,097.1	20,371.5	20,878.6	24,348.9	22,167.6	28,149.1	27,813.9	39,095.4	38,429.3
Enforcement and Compliance Monitoring (OECM)											
$ WQ	9,261.5	2,893.0	324.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	39,145.1	17,713.7	16,114.4	11,894.0	15,449.7	20,330.3	13,734.3	22,907.6	27,108.9	28,243.8	33,029.5
Solid Waste and Emergency Response (OSWER)											
$ WQ	0.0	5,450.1	3,127.5	1,831.4	2,222.6	1,829.4	1,679.2	1,747.5	1,640.3	2,145.4	1,382.5
$ TOTAL	0.0	67,399.9	161,442.7	190,792.9	369,498.7	221,557.4	160,583.8	381,884.1	478,306.7	445,982.5	1,486,252.6

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

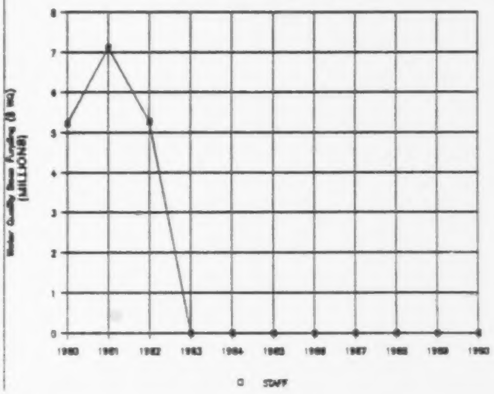
TABLE 1 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

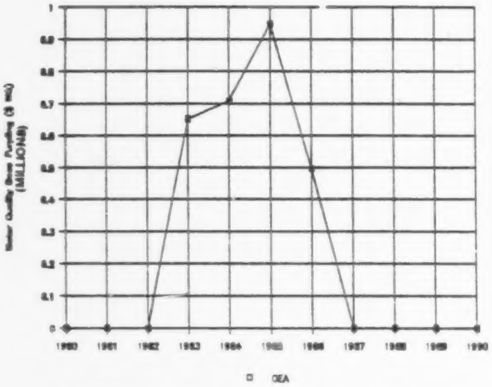
Water Quality Base Funding for Assistant Administrators

1980–1990

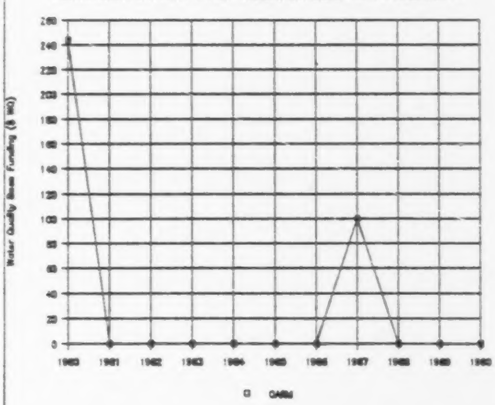
ADMINISTRATIVE STAFF



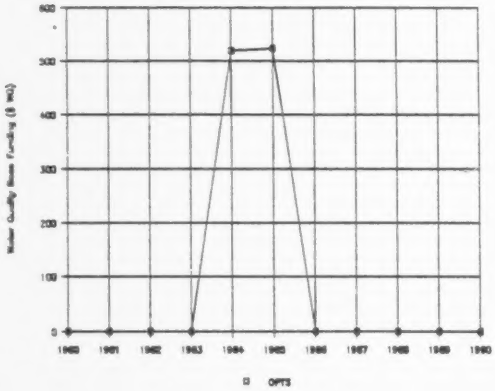
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

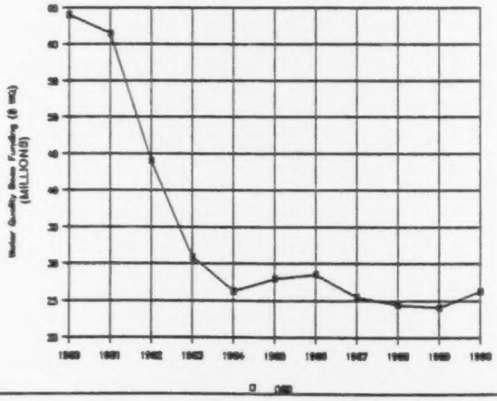


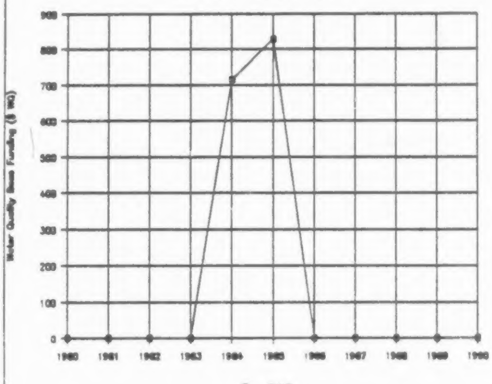
TABLE 1 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

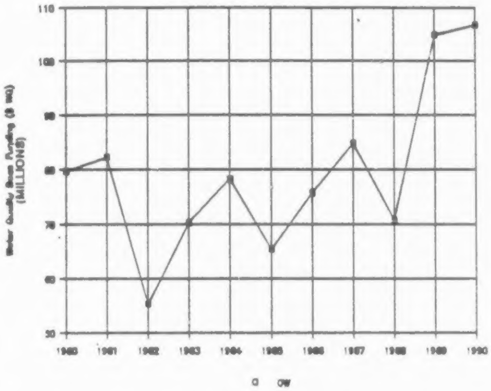
Water Quality Base Funding for Assistant Administrators

1980–1990

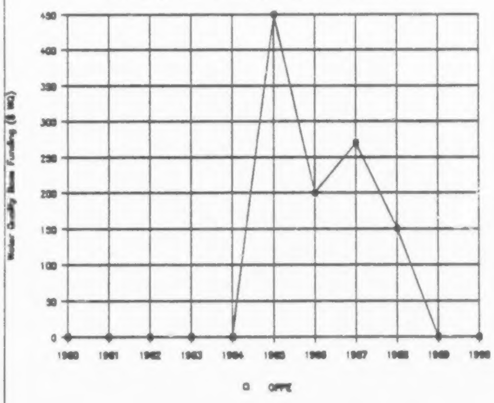
AIR AND RADIATION



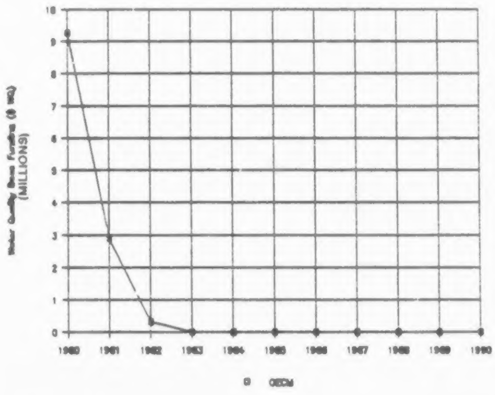
WATER



POLICY, PLANNING, AND EVALUATION



ENFORCEMENT AND COMPLIANCE MONITORING



SOLID WASTE AND EMERGENCY RESPONSE

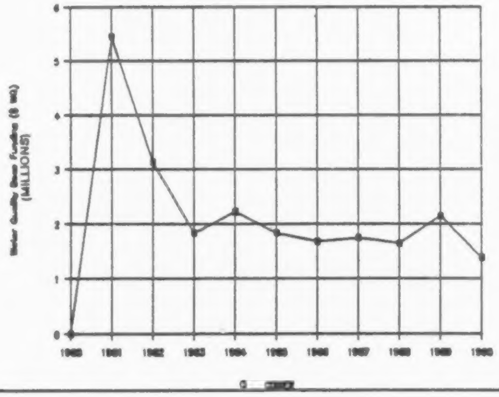


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TABLE 2 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Water Quality Funding Levels for Assistant Administrators

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
1982 GNP Deflator Index Values:	0.855	0.934	1	1.04	1.086	1.123	1.146	1.185	1.237	1.286	1.332
Administrative Staff (STAFF)											
$ WQ	6,110.2	7,620.4	5,267.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	28,563.4	33,360.6	34,655.3	6,588.6	7,683.9	7,812.3	7,779.9	7,762.1	8,723.4	10,391.5	10,022.4
External Affairs (OEA)											
c/ $ WQ	0.0	0.0	0.0	626.1	651.4	843.7	432.4	0.0	0.0	0.0	0.0
$ TOTAL	0.0	0.0	0.0	12,891.9	12,803.8	12,470.7	12,062.1	8,898.8	8,887.0	8,746.4	9,295.0
Administration and Resources Management (OARM)											
d/ $ WQ	285.3	0.0	0.0	0.0	0.0	0.0	0.0	84.4	0.0	0.0	0.0
$ TOTAL	139,796.3	130,206.6	136,132.7	129,558.8	132,091.1	161,542.4	142,935.0	192,011.5	227,817.1	221,005.1	236,299.1
Pesticides and Toxic Substances (OPTS)											
$ WQ	0.0	0.0	0.0	0.0	478.8	466.6	0.0	0.0	0.0	0.0	0.0
$ TOTAL	113,214.3	113,988.3	81,126.7	74,154.5	76,516.3	83,898.3	121,050.7	128,337.6	122,493.4	159,279.6	112,194.4
Research and Development (ORD)											
$ WQ	74,911.9	65,781.7	44,030.9	29,629.1	24,166.8	24,894.7	24,880.9	21,500.6	19,766.7	18,728.8	19,749.6
$ TOTAL	391,814.0	371,918.5	271,087.8	217,801.0	227,566.3	268,663.8	274,086.5	289,725.4	287,350.7	299,717.5	316,426.4
Air and Radiation (OA&R)											
$ WQ	0.0	0.0	0.0	0.0	658.4	738.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	105,204.8	99,836.6	66,964.7	61,978.7	63,417.4	65,520.7	66,984.7	71,627.8	72,116.0	79,154.7	86,243.9
Water (OW)											
b/ $ WQ	93,204.7	88,121.1	55,385.3	67,584.5	72,051.0	58,270.3	66,108.7	71,557.1	57,139.6	81,565.7	80,156.2
$ TOTAL	147,636.5	134,380.0	58,773.1	69,960.4	74,145.9	72,975.2	83,542.0	96,417.8	79,639.5	104,071.7	103,745.9
Policy, Planning, and Evaluation (OPPE)											
e/ $ WQ	0.0	0.0	0.0	0.0	0.0	400.7	174.5	227.8	121.5	0.0	0.0
$ TOTAL	0.0	18,340.8	22,097.1	19,588.0	19,225.2	21,682.0	19,343.5	23,754.5	22,485.0	30,400.8	28,850.8
Enforcement and Compliance Monitoring (OECM)											
$ WQ	10,832.2	3,097.4	324.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	45,783.7	18,965.4	16,114.4	11,436.5	14,226.2	18,103.6	11,984.6	19,331.3	21,915.0	21,962.5	24,796.9
Solid Waste and Emergency Response (OSWER)											
$ WQ	0.0	5,835.2	3,127.5	1,761.0	2,046.6	1,629.0	1,465.3	1,474.7	1,326.0	1,668.3	1,037.9
$ TOTAL	0.0	72,162.6	161,442.7	183,454.7	340,238.2	197,290.7	140,125.5	322,265.1	386,666.7	346,798.2	1,115,805.3

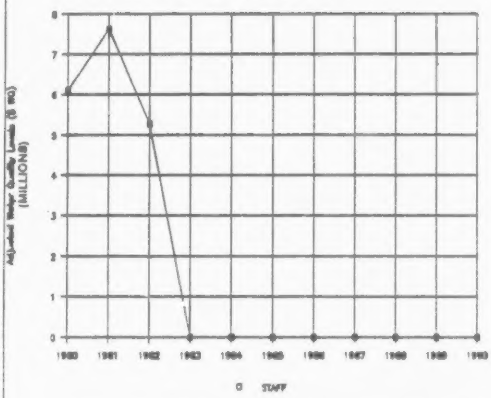
** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

TABLE 2 GRAPHS:

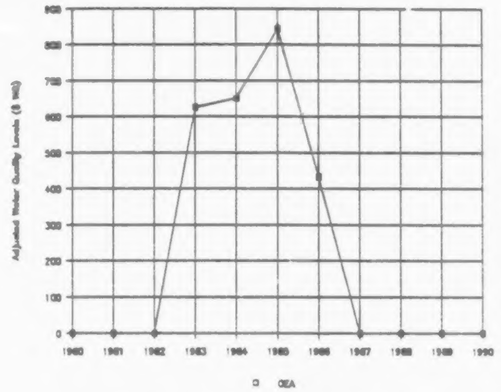
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Water Quality Funding Levels for Assistant Administrators

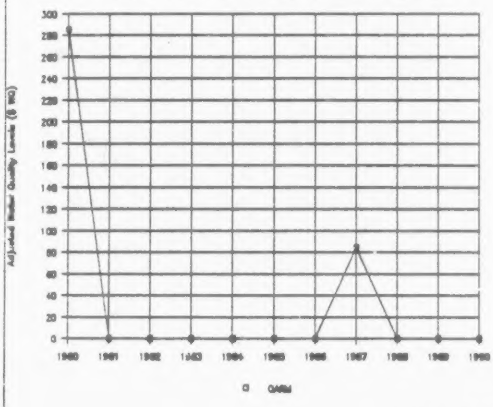
1980–1990



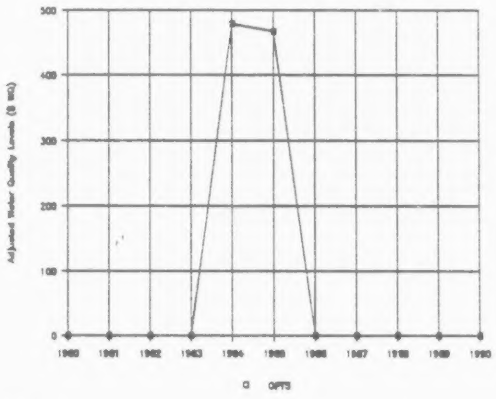
ADMINISTRATIVE STAFF



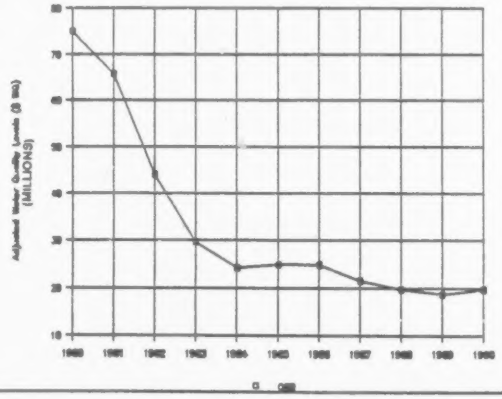
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

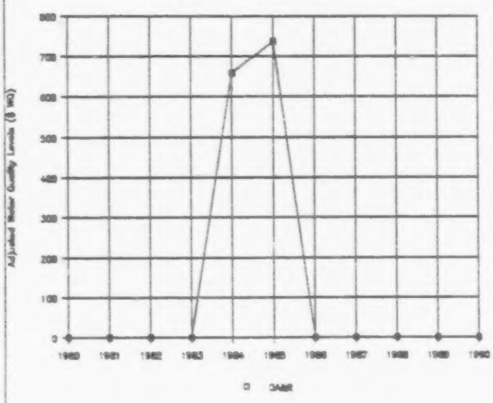
TABLE 2 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

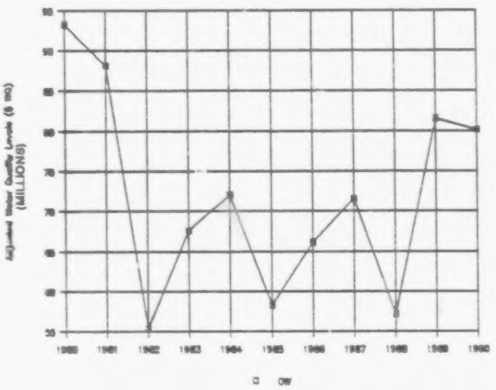
Adjusted Water Quality Funding Levels for Assistant Administrators

1980-1990

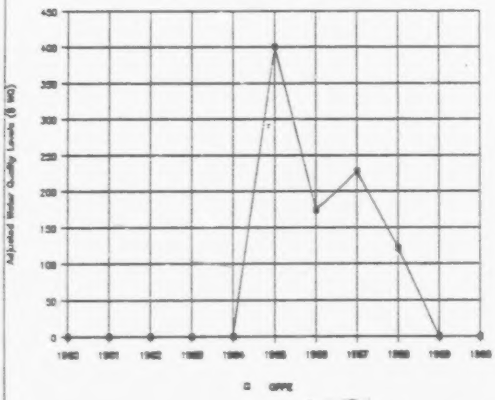
AIR AND RADIATION



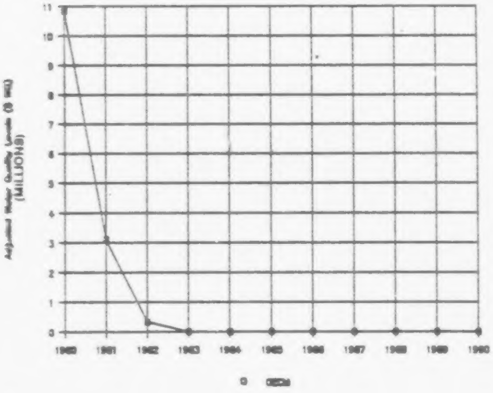
WATER



POLICY, PLANNING, AND EVALUATION



ENFORCEMENT AND COMPLIANCE MONITORING



SOLID WASTE AND EMERGENCY RESPONSE

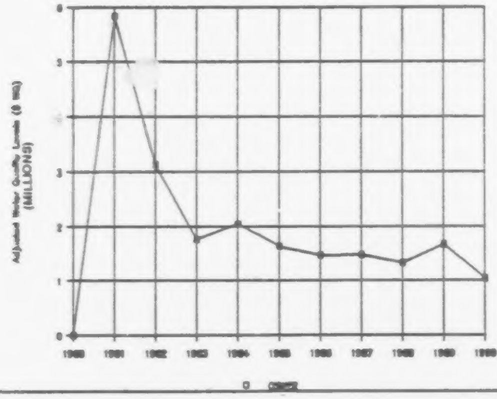


TABLE 3 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Water Quality Personnel Resources for Assistant Administrators

1980–1990

WQ = Water Quality FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
FTE WQ	0.0	12.3	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	474.4	464.3	490.3	137.6	156.9	164.3	169.3	170.1	170.1	186.6	186.1
External Affairs (OEA)											
c/ FTE WQ	0.0	0.0	0.0	8.2	8.2	12.7	12.7	0.0	0.0	0.0	0.0
FTE TOTAL	0.0	0.0	0.0	132.4	151.1	156.3	157.4	146.9	144.1	143.1	145.1
Administration and Resources Management (OARM)											
d/ FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	1,375.1	131.1	1,059.1	993.3	1,017.7	1,044.7	994.2	1,168.0	1,213.2	1,247.9	1,309.7
Pesticides and Toxic Substances (OPTS)											
FTE WQ	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	1,358.9	1,357.4	1,198.0	1,059.1	1,112.6	1,181.7	1,183.3	1,205.3	1,179.2	1,176.3	1,176.1
Research and Development (ORD)											
FTE WQ	742.6	641.0	542.6	416.2	313.8	302.6	319.6	296.9	277.0	267.0	266.0
FTE TOTAL	2,577.3	2,305.3	2,158.3	1,862.6	1,814.3	1,846.5	1,801.6	1,855.3	1,829.3	1,853.1	1,873.1
Air and Radiation (OA&R)											
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	1,011.9	1,121.9	912.2	784.5	765.0	815.9	840.7	874.5	871.2	881.0	903.0
Water (OW)											
b/ FTE WQ	596.1	625.2	563.4	499.1	504.6	396.1	393.0	415.7	419.0	420.4	420.2
FTE TOTAL	925.3	781.3	647.9	553.0	555.4	552.7	556.8	620.7	619.0	618.6	620.4
Policy, Planning, Evaluation (OPPE)											
e/ FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	0.0	274.2	262.2	206.2	225.8	228.6	225.8	237.9	227.9	235.9	237.2
Enforcement and Compliance Monitoring (OECM)											
FTE WQ	132.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	614.8	310.0	321.5	218.1	236.6	271.5	194.4	271.7	310.5	309.9	330.9
Solid Waste and Emergency Response (OSWER)											
FTE WQ	0.0	32.9	21.6	4.2	5.0	7.0	3.9	7.0	5.0	3.0	3.0
FTE TOTAL	0.0	281.3	363.3	374.8	441.2	533.3	346.1	637.7	737.3	715.9	687.5

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

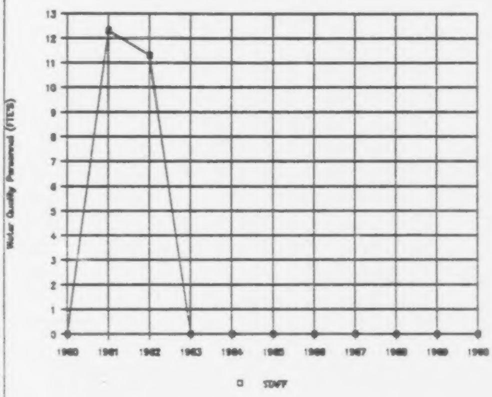
TABLE 3 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

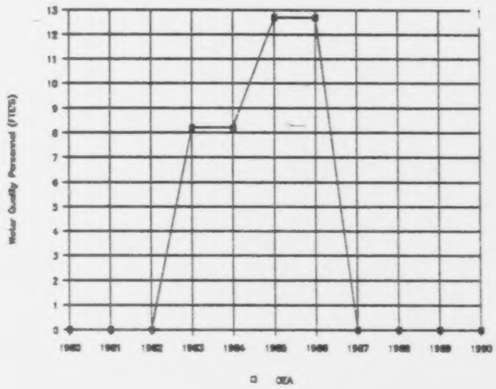
Water Quality Personnel Resources for Assistant Administrators

1980–1990

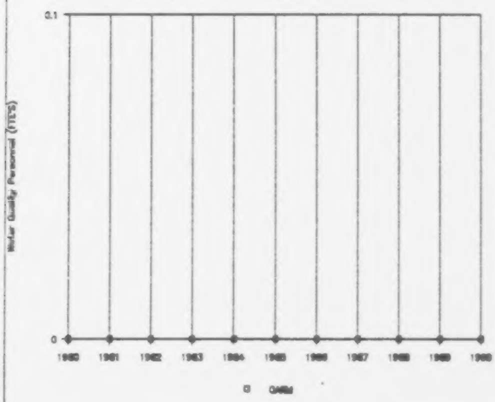
ADMINISTRATIVE STAFF



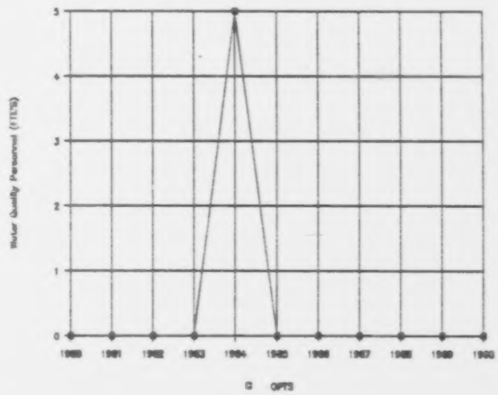
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

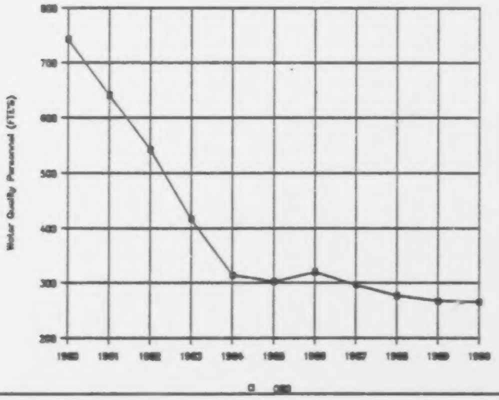
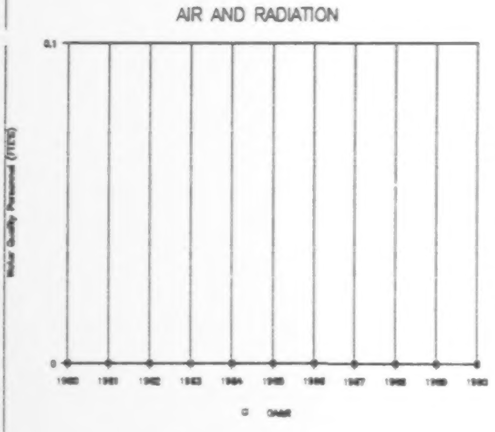


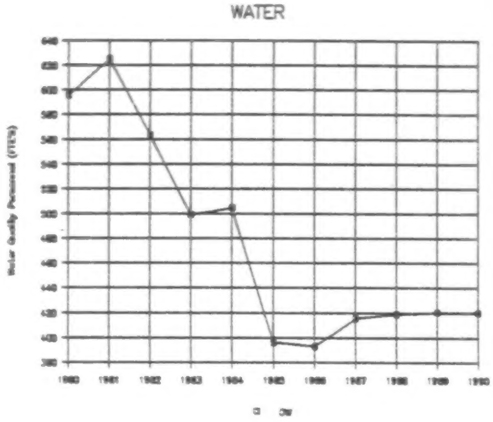
TABLE 3 GRAPHS:

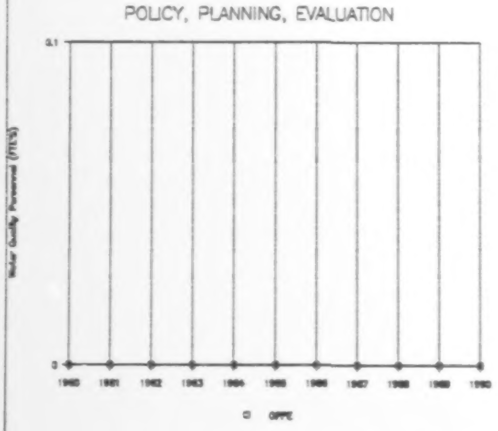
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

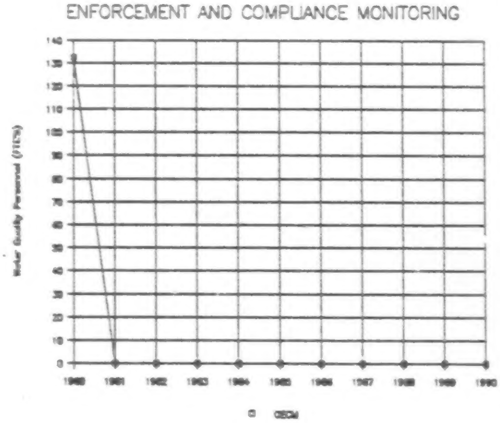
Water Quality Personnel Resources for Assistant Administrators

1980–1990


AIR AND RADIATION


WATER


POLICY, PLANNING, EVALUATION


ENFORCEMENT AND COMPLIANCE MONITORING

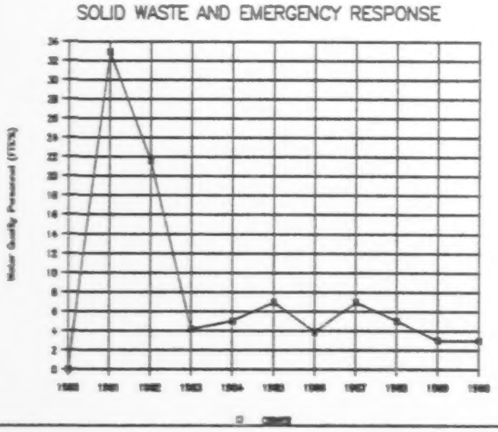

SOLID WASTE AND EMERGENCY RESPONSE

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TABLE 4 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Adjusted Funding Directed to Water Quality for Assistant Administrators

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
$ WQ	6,110.2	7,620.4	5,267.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	28,563.4	33,360.6	34,655.3	6,588.6	7,683.9	7,812.3	7,779.9	7,762.1	8,723.4	10,391.5	10,022.4
$ WQ/$ TOTAL (%)	21.4	22.8	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
External Affairs (OEA)											
c/$ WQ	0.0	0.0	0.0	626.1	651.4	843.7	432.4	0.0	0.0	0.0	0.0
$ TOTAL	0.0	0.0	0.0	12,891.9	12,803.8	12,470.7	12,062.1	8,898.8	8,887.0	8,746.4	9,295.0
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	4.9	5.1	6.8	3.6	0.0	0.0	0.0	0.0
Administration and Resources Management (OARM)											
d/$ WQ	285.3	0.0	0.0	0.0	0.0	0.0	0.0	84.4	0.0	0.0	0.0
$ TOTAL	139,796.3	130,206.6	136,132.7	129,558.8	132,091.1	161,542.4	142,935.0	192,011.5	227,817.1	221,005.1	236,299.1
$ WQ/$ TOTAL (%)	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pesticides and Toxic Substances (OPTS)											
$ WQ	0.0	0.0	0.0	0.0	478.8	466.6	0.0	0.0	0.0	0.0	0.0
$ TOTAL	113,214.3	113,988.3	81,126.7	74,154.5	76,516.3	83,898.3	121,050.7	128,337.6	122,493.4	159,279.6	112,194.4
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0
Research and Development (ORD)											
$ WQ	74,911.9	65,781.7	44,030.9	29,629.1	24,166.8	24,894.7	24,880.9	21,500.6	19,766.7	18,728.8	19,749.6
$ TOTAL	391,814.0	371,918.5	271,087.8	217,801.0	227,566.3	268,663.8	274,086.5	289,725.4	287,350.7	299,717.5	316,426.4
$ WQ/$ TOTAL (%)	19.1	17.7	16.2	13.6	10.6	9.3	9.1	7.4	6.9	6.2	6.2
Air and Radiation (OA&R)											
$ WQ	0.0	0.0	0.0	0.0	658.4	738.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	105,204.8	99,836.6	66,964.7	61,978.7	63,417.4	65,520.7	68,984.7	71,627.8	72,116.0	79,154.7	86,243.9
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	0.0	1.0	1.1	0.0	0.0	0.0	0.0	0.0
Water (OW)											
b/$ WQ	93,204.7	88,121.1	55,385.3	67,584.5	72,051.0	58,270.3	66,108.7	71,557.1	57,139.6	81,565.7	80,156.2
$ TOTAL	147,636.5	134,380.0	58,773.1	69,960.4	74,145.9	72,975.2	83,542.0	96,417.8	79,639.5	104,071.7	103,745.9
$ WQ/$ TOTAL (%)	**63.1**	**65.6**	**94.2**	**96.6**	**97.2**	**79.8**	**79.1**	**74.2**	**71.7**	**78.4**	**77.3**
Policy, Planning, and Evaluation (OPPE)											
e/$ WQ	0.0	0.0	0.0	0.0	0.0	400.7	174.5	227.8	121.5	0.0	0.0
$ TOTAL	0.0	18,340.8	22,097.1	19,588.0	19,225.2	21,682.0	19,343.5	23,754.5	22,485.0	30,400.8	28,850.8
$ WQ/$ TOTAL (%)	0.0	0.0	0.0	0.0	0.0	1.8	0.9	1.0	0.5	0.0	0.0
Enforcement and Compliance Monitoring (OECM)											
$ WQ	10,832.2	3,097.4	324.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ TOTAL	45,783.7	18,965.4	16,114.4	11,438.5	14,226.2	18,103.6	11,984.6	19,331.3	21,915.0	21,962.5	24,796.9
$ WQ/$ TOTAL (%)	23.7	16.3	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid Waste and Emergency Response (OSWER)											
$ WQ	0.0	5,835.2	3,127.5	1,761.0	2,046.6	1,629.0	1,465.3	1,474.7	1,326.0	1,668.3	1,037.9
$ TOTAL	0.0	72,162.6	161,442.7	183,454.7	340,238.2	197,290.7	140,125.5	322,265.1	386,666.7	346,798.2	1,115,805.3
$ WQ/$ TOTAL (%)	0.0	8.1	1.9	1.0	0.6	0.8	1.0	0.5	0.3	0.5	0.1

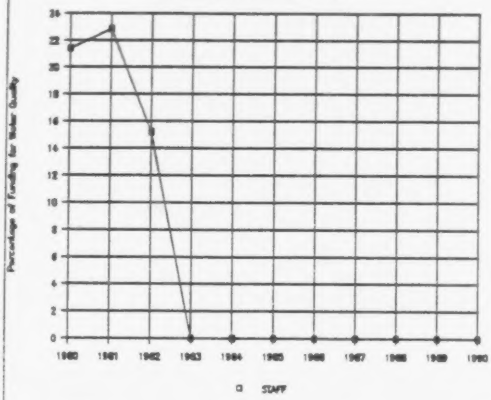
** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

TABLE 4 OF 8:

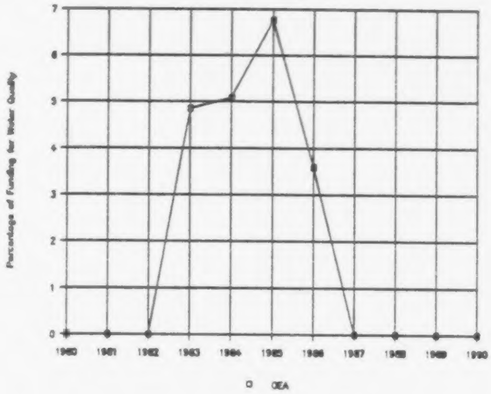
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Adjusted Funding Directed to Water Quality for Assistant Administrators 1980–1990

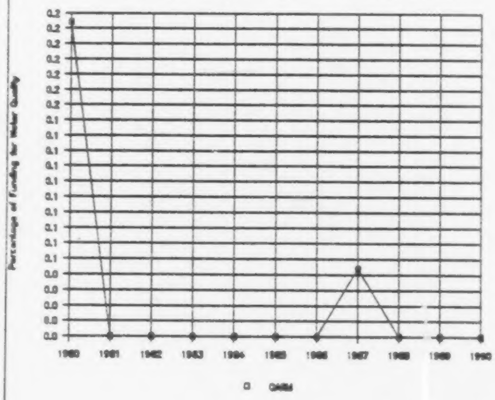
ADMINISTRATIVE STAFF



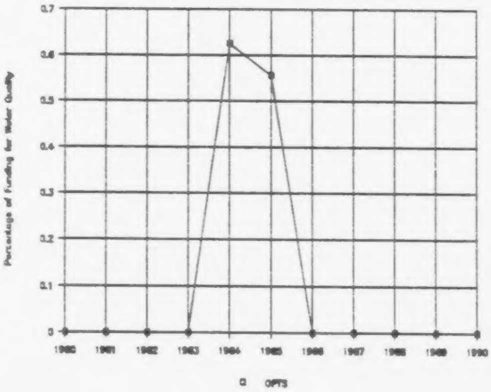
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

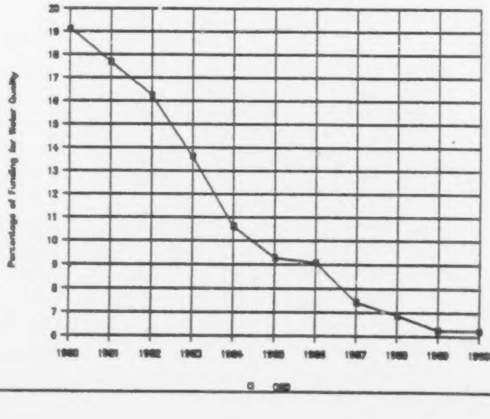


TABLE 4 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Adjusted Funding Directed to Water Quality for Assistant Administrators
1980–1990

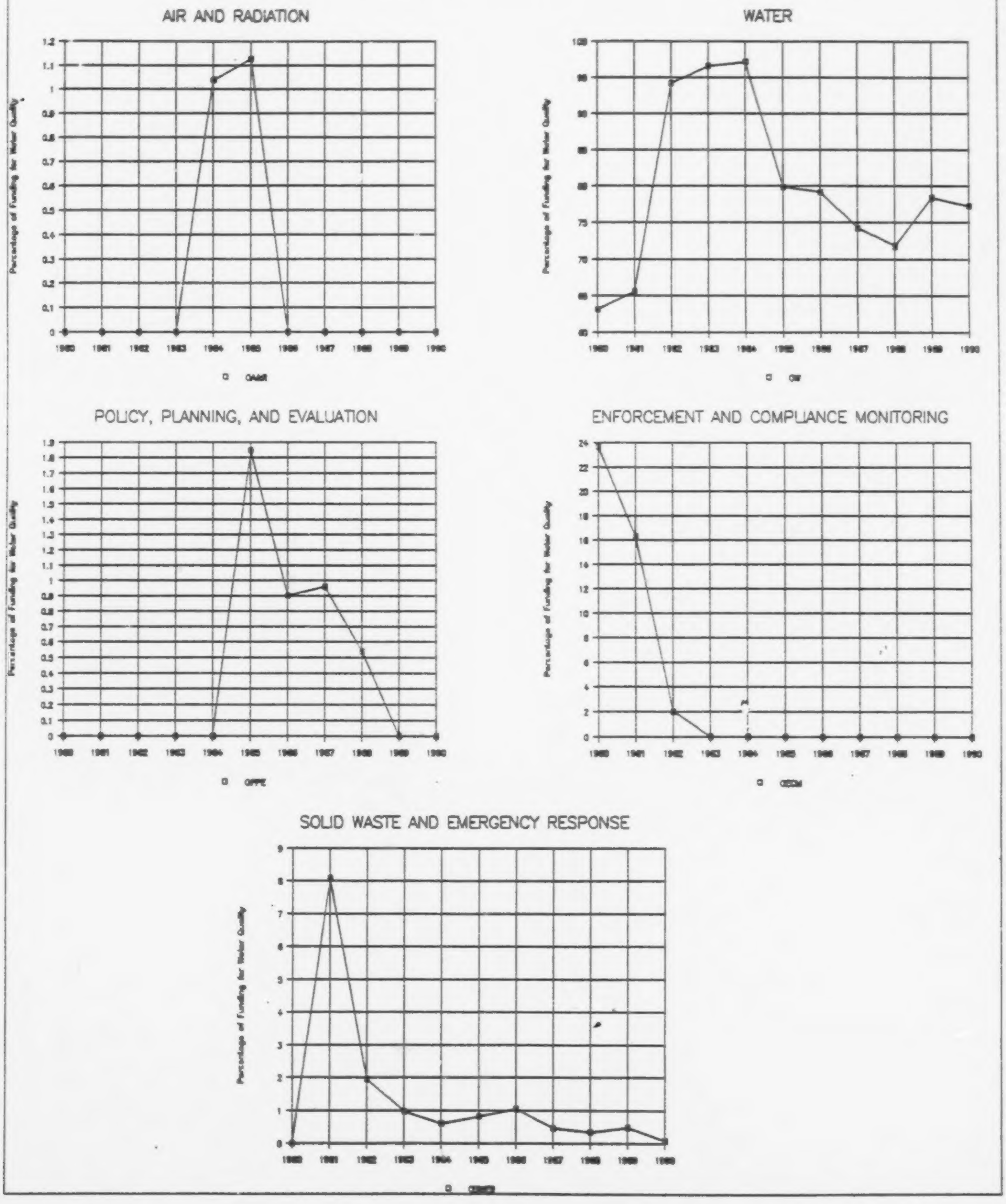


TABLE 5 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Total Personnel Assigned to Water Quality for Assistant Administrators

1980–1990

WQ = Water Quality

FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
FTE WQ	0.0	12.3	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	474.4	464.3	490.3	137.6	156.9	164.3	169.3	170.1	170.1	186.6	186.1
FTE WQ/FTE TOTAL (%)	0.0	2.6	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
External Affairs (OEA)											
FTE WQ	0.0	0.0	0.0	8.2	8.2	12.7	12.7	0.0	0.0	0.0	0.0
FTE TOTAL	0.0	0.0	0.0	132.4	151.1	156.3	157.4	146.9	144.1	143.1	145.1
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	6.2	5.4	8.1	8.1	0.0	0.0	0.0	0.0
Administration and Resources Management (OARM)											
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	1,375.1	131.1	1,059.1	993.3	1,017.7	1,044.7	994.2	1,168.0	1,213.2	1,247.9	1,309.7
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pesticides and Toxic Substances (OPTS)											
FTE WQ	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	1,358.9	1,357.4	1,198.0	1,059.1	1,112.6	1,181.7	1,183.3	1,205.3	1,179.2	1,176.3	1,176.1
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Research and Development (ORD)											
FTE WQ	742.6	641.0	542.6	416.2	313.8	302.6	319.6	296.9	277.0	267.0	266.0
FTE TOTAL	2,577.3	2,305.3	2,158.3	1,862.6	1,814.3	1,846.5	1,801.6	1,855.3	1,829.3	1,853.1	1,873.1
FTE WQ/FTE TOTAL (%)	28.8	27.8	25.1	22.3	17.3	16.4	17.7	16.0	15.1	14.4	14.2
Air and Radiation (OA&R)											
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	1,011.9	1,121.9	912.2	784.5	765.0	815.9	840.7	874.5	871.2	881.0	903.0
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Water (OW)											
FTE WQ	596.1	625.2	563.4	499.1	504.6	396.1	393.0	415.7	419.0	420.4	420.2
FTE TOTAL	925.3	781.3	647.9	553.0	555.4	552.7	556.8	620.7	619.0	618.6	620.4
FTE WQ/FTE TOTAL (%)	64.4	80.0	87.0	90.3	90.9	71.7	70.6	67.0	67.7	68.0	67.7
Policy, Planning, Evaluation (OPPE)											
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	0.0	274.2	262.2	206.2	225.8	228.6	225.8	237.9	227.9	235.9	237.2
FTE WQ/FTE TOTAL (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enforcement and Compliance Monitoring (OECM)											
FTE WQ	132.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE TOTAL	614.8	310.0	321.5	218.1	236.6	271.5	194.4	271.7	310.5	309.9	330.9
FTE WQ/FTE TOTAL (%)	21.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid Waste and Emergency Response (OSWER)											
FTE WQ	0.0	32.9	21.6	4.2	5.0	7.0	3.9	7.0	5.0	3.0	3.0
FTE TOTAL	0.0	281.3	363.3	374.8	441.2	533.3	346.1	637.7	737.3	715.9	687.5
FTE WQ/FTE TOTAL (%)	0.0	11.7	5.9	1.1	1.1	1.3	1.1	1.1	0.7	0.4	0.4

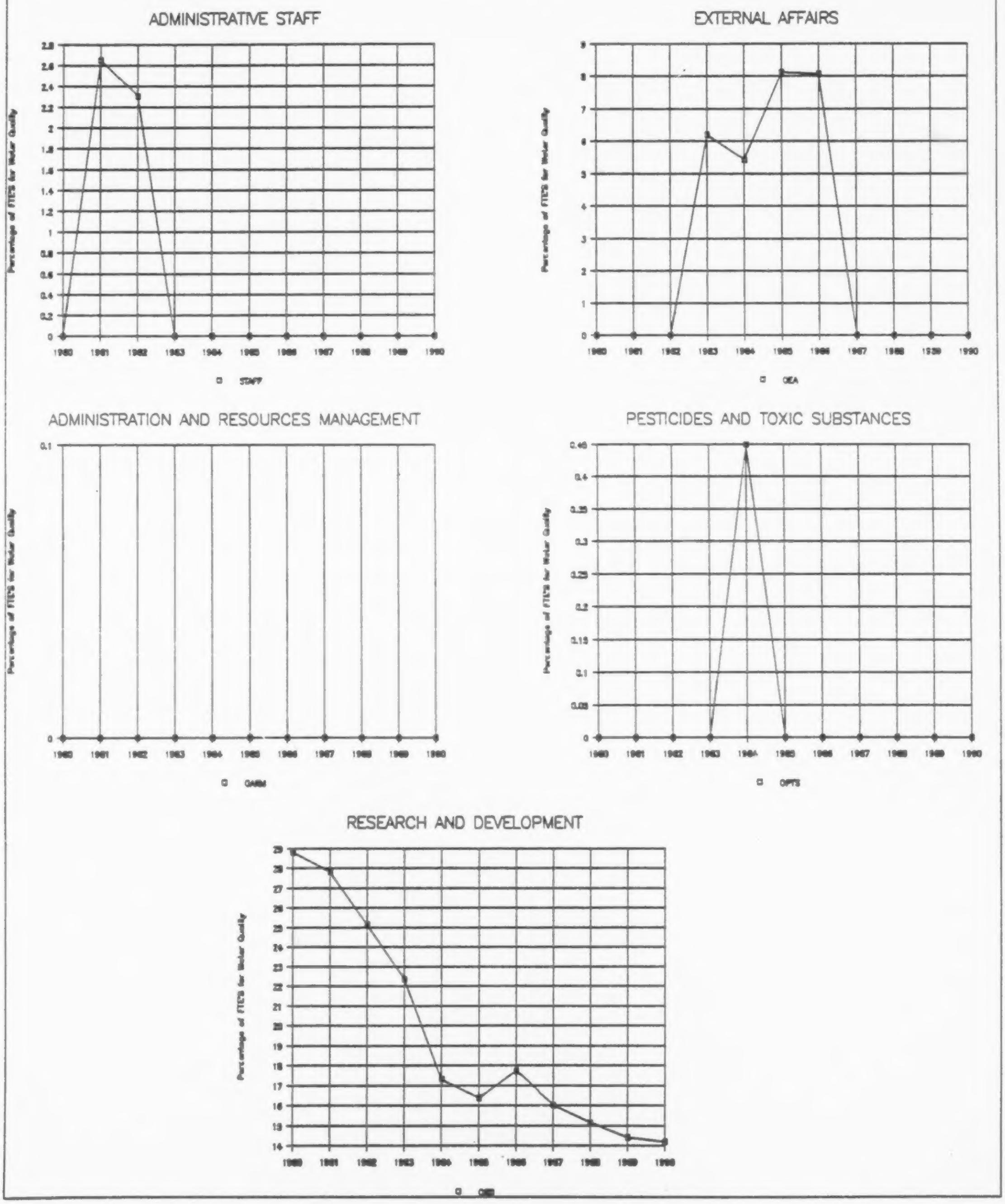
** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

TABLE 5 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Total Personnel Assigned to Water Quality for Assistant Administrators

1980-1990



ADMINISTRATIVE STAFF

EXTERNAL AFFAIRS

ADMINISTRATION AND RESOURCES MANAGEMENT

PESTICIDES AND TOXIC SUBSTANCES

RESEARCH AND DEVELOPMENT

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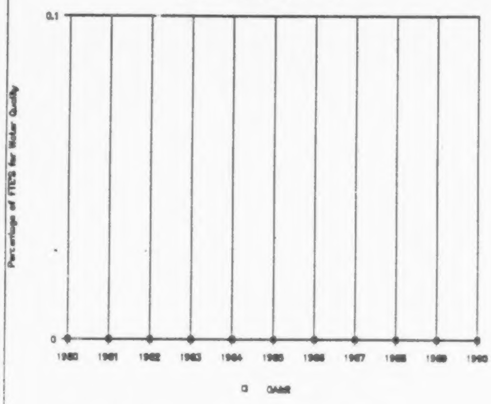
TABLE 5 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

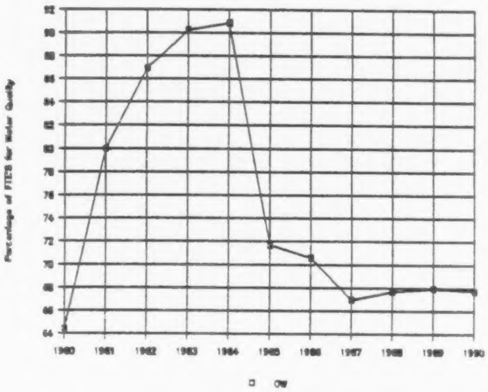
Percentage of Total Personnel Assigned to Water Quality for Assistant Administrators

1980–1990

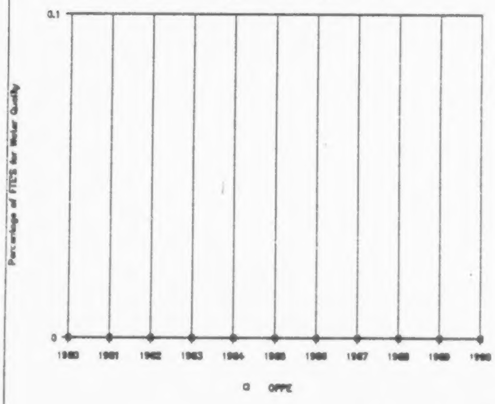
AIR AND RADIATION



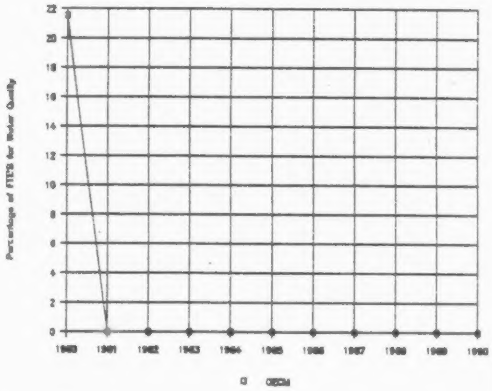
WATER



POLICY, PLANNING, AND EVALUATION



ENFORCEMENT AMD COMPLIANCE MONITORING



SOLID WASTE AND EMERGENCY RESPONSE

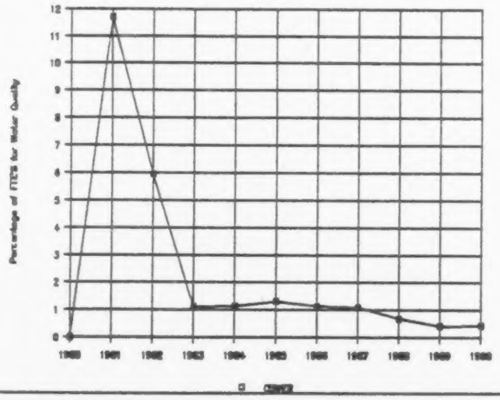


TABLE 6 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Assistant Administrators

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
$ WQ	6,110.2	7,620.4	5,267.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE WQ	0.0	12.3	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ WQ/FTE WQ #		619.5	466.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
External Affairs (OEA)											
c/$ WQ	0.0	0.0	0.0	626.1	651.4	843.7	432.4	0.0	0.0	0.0	0.0
FTE WQ	0.0	0.0	0.0	8.2	8.2	12.7	12.7	0.0	0.0	0.0	0.0
$ WQ/FTE WQ	0.0	0.0	0.0	76.3	79.4	66.4	34.0	0.0	0.0	0.0	0.0
Administration and Resources Management (OARM)											
d/$ WQ	285.3	0.0	0.0	0.0	0.0	0.0	0.0	84.4	0.0	0.0	0.0
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ WQ/FTE WQ #		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
Pesticides and Toxic Substances (OPTS)											
$ WQ	0.0	0.0	0.0	0.0	478.8	466.6	0.0	0.0	0.0	0.0	0.0
FTE WQ	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
$ WQ/FTE WQ #	0.0	0.0	0.0	0.0	95.8		0.0	0.0	0.0	0.0	0.0
Research and Development (ORD)											
$ WQ	74,911.9	65,781.7	44,030.9	29,629.1	24,166.8	24,894.7	24,880.9	21,500.6	19,766.7	18,728.8	19,749.6
FTE WQ	742.6	641.0	542.6	416.2	313.8	302.6	319.6	296.9	277.0	267.0	266.0
$ WQ/FTE WQ	100.9	102.6	81.1	71.2	77.0	82.3	77.9	72.4	71.4	70.1	74.2
Air and Radiation (OA&R)											
$ WQ	0.0	0.0	0.0	0.0	658.4	738.0	0.0	0.0	0.0	0.0	0.0
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ WQ/FTE WQ #	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0
Water (OW)											
b/$ WQ	93,204.7	88,121.1	55,385.3	67,584.5	72,051.0	58,270.3	66,108.7	71,557.1	57,139.6	81,565.7	80,156.2
FTE WQ	596.1	625.2	563.4	499.1	504.6	396.1	393.0	415.7	419.0	420.4	420.2
$ WQ/FTE WQ	156.4	140.9	98.3	135.4	142.8	147.1	168.2	172.1	136.4	194.0	190.8
Policy, Planning, and Evaluation (OPPE)											
e/$ WQ	0.0	0.0	0.0	0.0	0.0	400.7	174.5	227.8	121.5	0.0	0.0
FTE WQ	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ WQ/FTE WQ #	0.0	0.0	0.0	0.0	0.0					0.0	0.0
Enforcement and Compliance Monitoring (OECM)											
$ WQ	10,832.2	3,097.4	324.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FTE WQ	132.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$ WQ/FTE WQ #	81.8			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid Waste and Emergency Response (OSWER)											
$ WQ	0.0	5,835.2	3,127.5	1,761.0	2,046.6	1,629.0	1,465.3	1,474.7	1,326.0	1,668.3	1,037.9
FTE WQ	0.0	32.9	21.6	4.2	5.0	7.0	3.9	7.0	5.0	3.0	3.0
$ WQ/FTE WQ	0.0	177.4	144.8	419.3	409.3	232.7	375.7	210.7	265.2	556.1	346.0

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

# Because the denominator of the intended numerical ratio is equal to zero, no numerical relationship can be demonstrated in the empty cells.

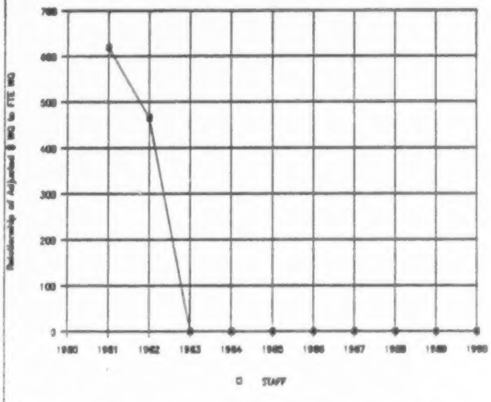
TABLE 6 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

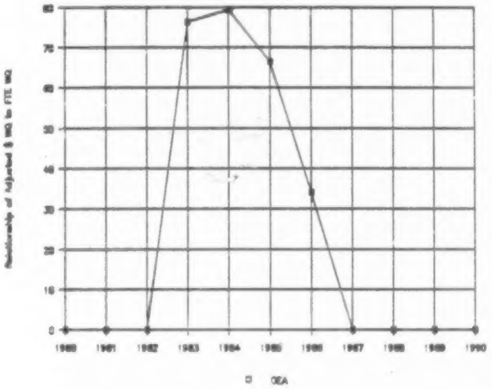
Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Assistant Administrators

1980–1990

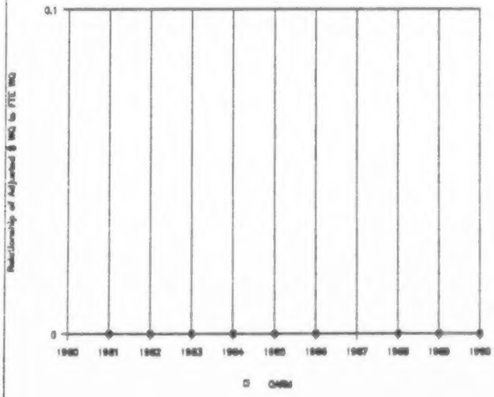
ADMINISTRATIVE STAFF



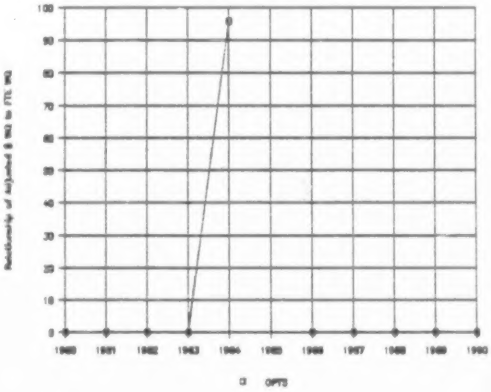
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

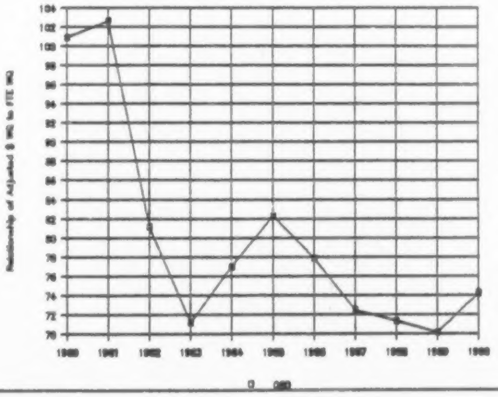


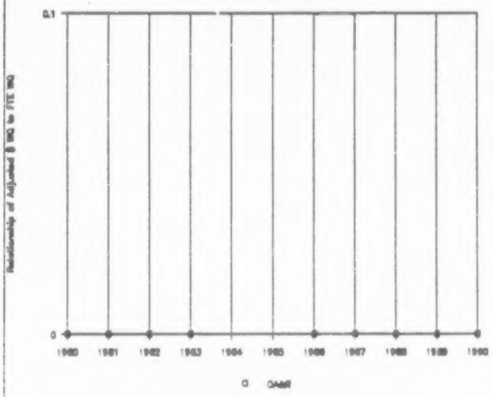
TABLE 6 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

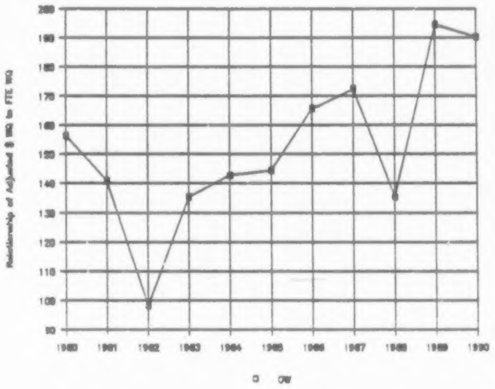
Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Assistant Administrators

1980–1990

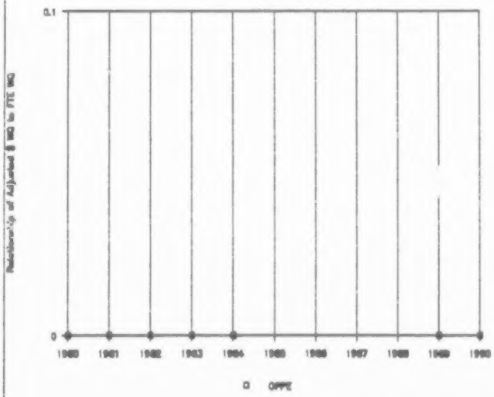
AIR AND RADIATION



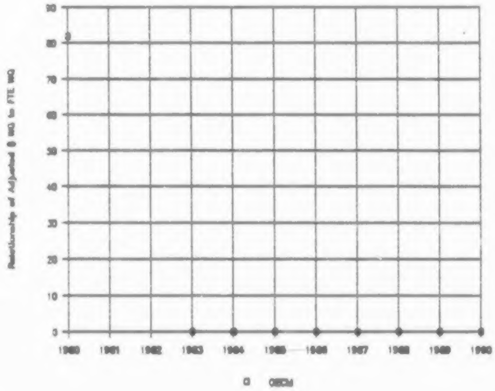
WATER



POLICY, PLANNING, AND EVALUATION



ENFORCEMENT AND COMPLIANCE MONITORING



SOLID WASTE AND EMERGENCY RESPONSE

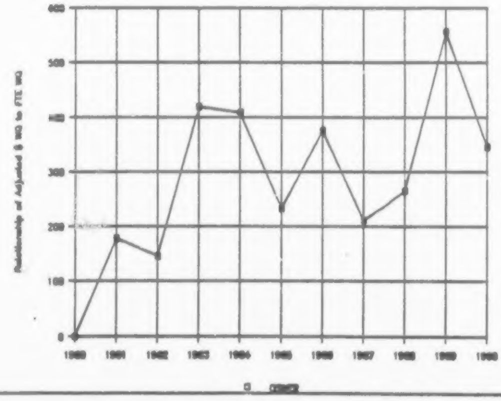


TABLE 7 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Relationship of Adjusted Total Funding to Total Personnel for Assistant Administrators

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
$ TOTAL	28,563.4	33,360.6	34,655.3	6,588.6	7,683.9	7,812.3	7,779.9	7,762.1	8,723.4	10,391.5	10,022.4
FTE TOTAL	474.4	464.3	490.3	137.6	156.9	164.3	169.3	170.1	170.1	186.6	186.1
$ TOTAL/FTE TOTAL	60.2	71.9	70.7	47.9	49.0	47.5	46.0	45.6	51.3	55.7	53.9
External Affairs (OEA)											
$ TOTAL	0.0	0.0	0.0	12,891.9	12,803.8	12,470.7	12,062.1	8,898.8	8,887.0	8,746.4	9,295.0
FTE TOTAL	0.0	0.0	0.0	132.4	151.1	156.3	157.4	146.9	144.1	143.1	145.1
$ TOTAL/FTE TOTAL	0.0	0.0	0.0	97.4	84.7	79.8	76.6	60.6	61.7	61.1	64.1
Administration and Resources Management (OARM)											
$ TOTAL	139,796.3	130,206.6	136,132.7	129,558.8	132,091.1	161,542.4	142,935.0	192,011.5	227,817.1	221,005.1	236,299.1
FTE TOTAL	1,375.1	131.1	1,059.1	993.3	1,017.7	1,044.7	994.2	1,168.0	1,213.2	1,247.9	1,309.7
$ TOTAL/FTE TOTAL	101.7	993.2	128.5	130.4	129.8	154.6	143.8	164.4	187.8	177.1	180.4
Pesticides and Toxic Substances (OPTS)											
$ TOTAL	113.214.3	113,988.3	81,126.7	74,154.5	76,516.3	83,898.3	121,050.7	128,337.6	122,493.4	159,279.6	112,194.4
FTE TOTAL	1,358.9	1,357.4	1,198.0	1,059.1	1,112.6	1,181.7	1,183.3	1,205.3	1,179.2	1,176.3	1,176.1
$ TOTAL/FTE TOTAL	83.3	84.0	67.7	70.0	68.8	71.0	102.3	106.5	103.9	135.4	95.4
Research and Development (ORD)											
$ TOTAL	391,814.0	371,918.5	271,087.8	217,801.0	227,566.3	268,663.8	274,086.5	289,725.4	287,350.7	299,717.5	316,426.4
FTE TOTAL	2,577.3	2,305.3	2,158.3	1,862.6	1,814.3	1,846.5	1,801.6	1,855.3	1,829.3	1,853.1	1,873.1
$ TOTAL/FTE TOTAL	152.0	161.3	125.6	116.9	125.4	145.5	152.1	156.2	157.1	161.7	168.9
Air and Radiation (OA&R)											
$ TOTAL	105,204.8	99,836.6	66,964.7	61,978.7	63,417.4	65,520.7	66,984.7	71,627.8	72,116.0	79,154.7	86,243.9
FTE TOTAL	1,011.9	1,121.9	912.2	784.5	765.0	815.9	840.7	874.5	871.2	881.0	903.0
$ TOTAL/FTE TOTAL	104.0	89.0	73.4	79.0	82.9	80.3	79.7	81.9	82.8	89.8	95.5
Water (OW)											
$ TOTAL	147,636.5	134,380.0	58,773.1	69,960.4	74,145.9	72,975.2	83,542.0	96,417.8	79,639.5	104,071.7	103,745.9
FTE TOTAL	925.3	781.3	647.9	553.0	555.4	552.7	556.8	620.7	619.0	618.6	620.4
$ TOTAL/FTE TOTAL	159.6	172.0	90.7	126.5	133.5	132.0	150.0	155.3	128.7	168.2	167.2
Policy, Planning, Evaluation (OPPE)											
$ TOTAL	0.0	18,340.8	22,097.1	19,588.0	19,225.2	21,682.0	19,343.5	23,754.5	22,485.0	30,400.8	28,850.8
FTE TOTAL	0.0	274.2	262.2	206.2	225.8	228.6	225.8	237.9	227.9	235.9	237.2
$ TOTAL/FTE TOTAL	0.0	66.9	84.3	95.0	85.1	94.8	85.7	99.9	98.7	128.9	121.6
Enforcement and Compliance Monitoring (OECM)											
$ TOTAL	45,783.7	18,965.4	16,114.4	11,436.5	14,226.2	18,103.6	11,984.6	19,331.3	21,915.0	21,962.5	24,796.9
FTE TOTAL	614.8	310.0	321.5	218.1	236.6	271.5	194.4	271.7	310.5	309.9	330.9
$ TOTAL/FTE TOTAL	74.5	61.2	50.1	52.4	60.1	66.7	61.6	71.1	70.6	70.9	74.9
Solid Waste and Emergency Response (OSWER)											
$ TOTAL	0.0	72,162.6	161,442.7	183,454.7	340,238.2	197,290.7	140,125.5	322,265.1	386,666.7	346,798.2	1,115,805.3
FTE TOTAL	0.0	281.3	363.3	374.8	441.2	533.3	346.1	637.7	737.3	715.9	687.5
$ TOTAL/FTE TOTAL	0.0	256.5	444.4	489.5	771.2	369.9	404.9	505.4	524.4	484.4	1623.0

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

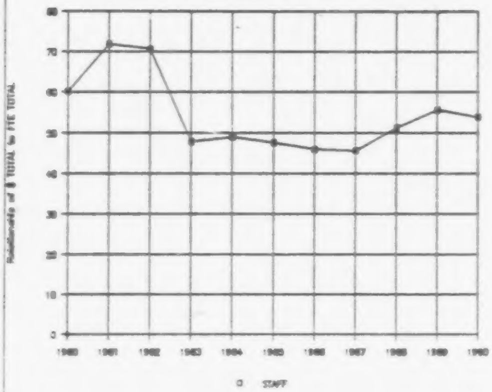
# Because the denominator of the intended numerical ratio is equal to zero, no numerical relationship can be demonstrated in the empty cells.

TABLE 7 GRAPHS:

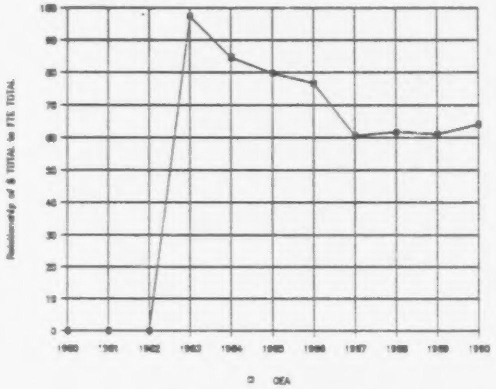
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Relationship of Adjusted Total Funding to Total Personnel for Assistant Administrators

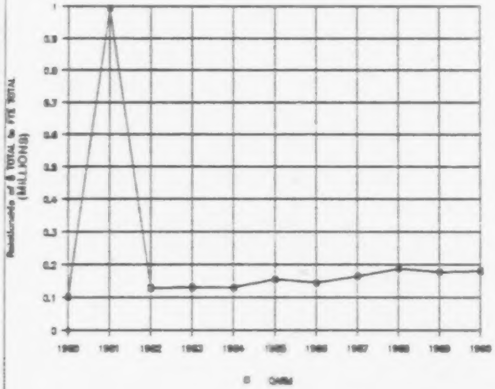
1980–1990



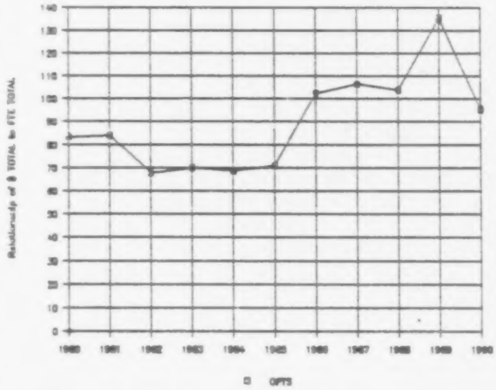
ADMINISTRATIVE STAFF



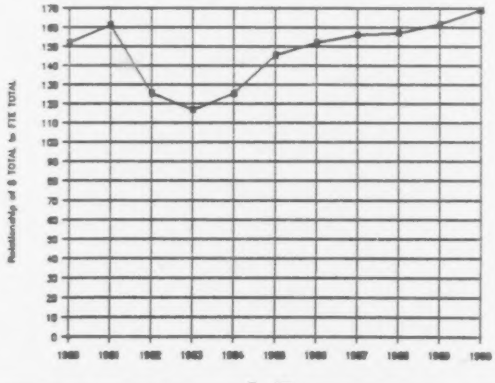
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

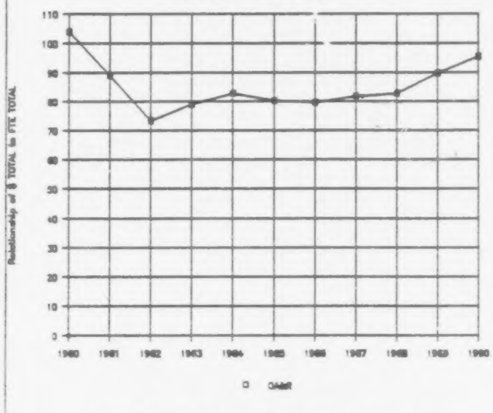
TABLE 7 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

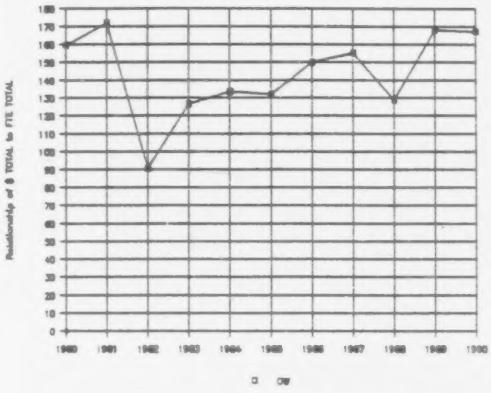
Relationship of Adjusted Total Funding to Total Personnel for Assistant Administrators

1980–1990

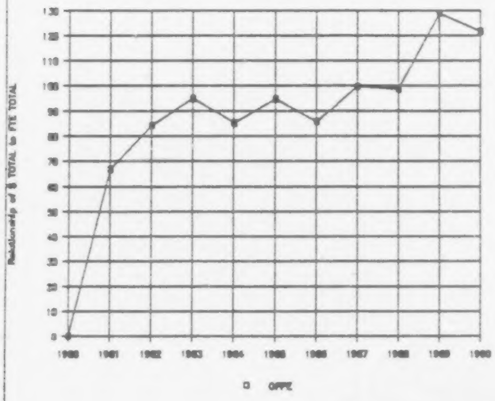
AIR AND RADIATION



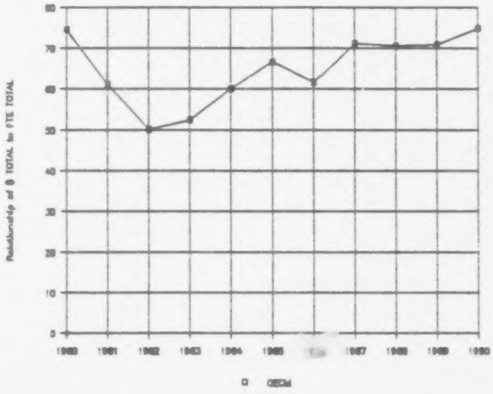
WATER



POLICY, PLANNING, AND EVALUATION



ENFORCEMENT AND COMPLIANCE MONITORING



SOLID WASTE AND EMERGENCY RESPONSE

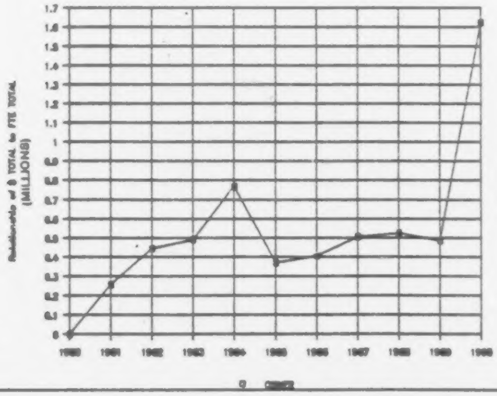


TABLE 8 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Assistant Administrators

1980–1990

WQ = Water Quality

$ = Appropriated Funds

FTE = Full -Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Administrative Staff (STAFF)											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL		8.6	6.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
External Affairs (OEA)											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.8	0.9	0.8	0.4	0.0	0.0	0.0	0.0
Administration and Resources Management (OARM)											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL		0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0
Pesticides and Toxic Substances (OPTS)											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.0	1.4		0.0	0.0	0.0	0.0	0.0
Research and Development (ORD)											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.4	0.4
Air and Radiation (OA&R)											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0	0.0
Water (OW)											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	0.8	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.1
Policy, Planning, and Evaluation (OPPE)											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL	0.0	0.0	0.0	0.0	0.0					0.0	0.0
Enforcement and Compliance Monitoring (OECM)											
$ WQ/FTE WQ # $ TOTAL/FTE TOTAL	1.1			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Solid Waste and Emergency Response (OSWER)											
$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.0	0.7	0.3	0.9	0.5	0.6	0.9	0.4	0.5	1.1	0.2

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

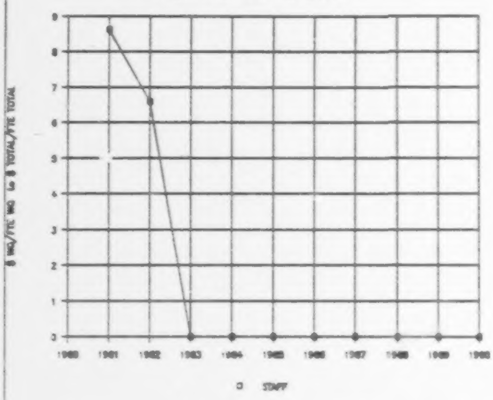
# Because the denominator of the intended numerical ratio is equal to zero, no numerical relationship can be demonstrated in the empty cells.

TABLE 8 GRAPHS:

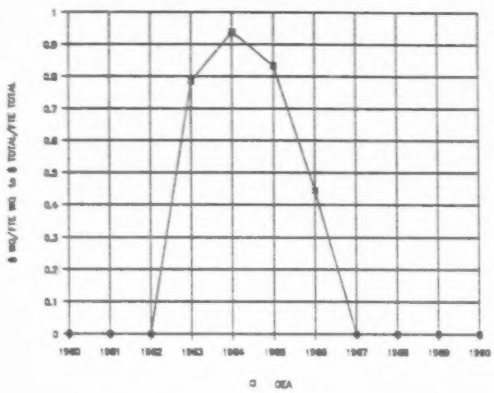
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Assistant Administrators

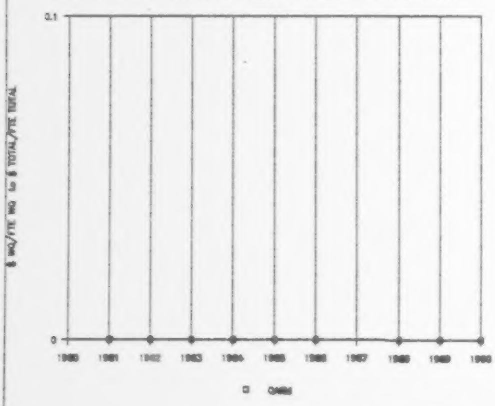
1980-1990



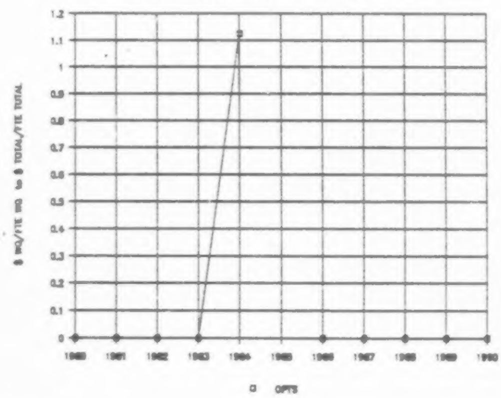
ADMINISTRATIVE STAFF



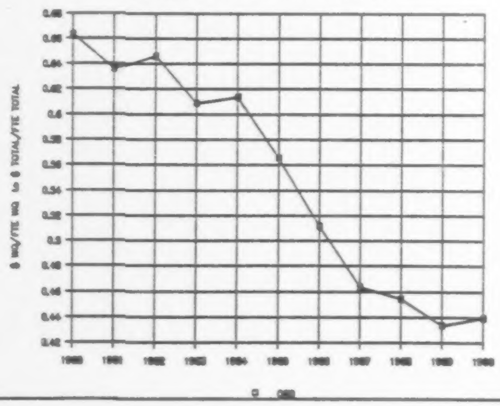
EXTERNAL AFFAIRS



ADMINISTRATION AND RESOURCES MANAGEMENT



PESTICIDES AND TOXIC SUBSTANCES



RESEARCH AND DEVELOPMENT

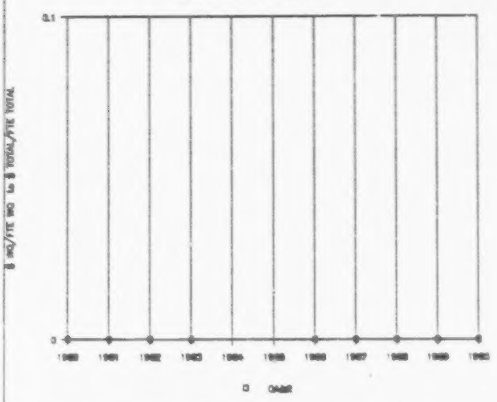
TABLE 8 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

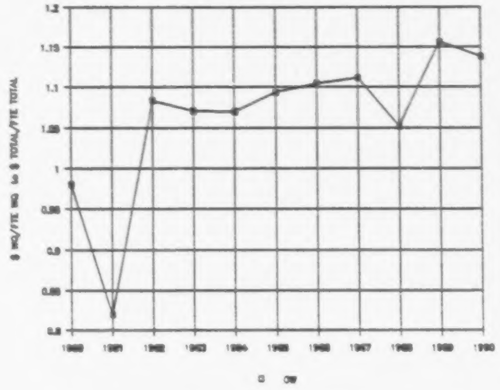
Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Assistant Administrators

1980–1990

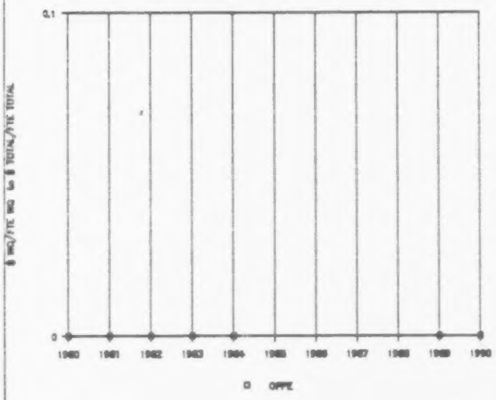
AIR AND RADIATION



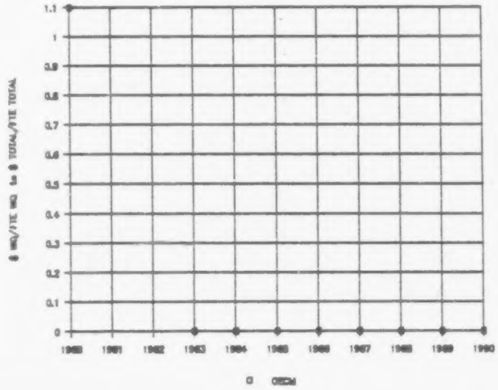
WATER



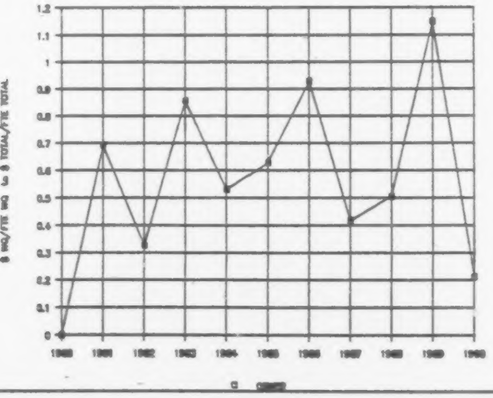
POLICY, PLANNING, AND EVALUATION



ENFORCEMENT AND COMPLIANCE MONITORING



SOLID WASTE AND EMERGENCY RESPONSE



FOOTNOTES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S ASSISTANT ADMINISTRATORS TABLES 1-8:

* Note: No overlap in appropriated funding exists between the administrators' and the regional offices' tables.

a/ The regional breakdowns of the President's FY 1990 Budget Request does not become available until the appeals process is completed in late 1989.

The following is authorizing legislation for the Environmental Protection Agency in the area of ground-water:

1. Federal Water Pollution Control Act of 1972 (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-217) as amended by the Water Quality Act of 1987 (P.L. 100-4).
2. The Safe Drinking Act of 1974 (P.L. 93-523); the Safe Drinking Water amendments of 1977 (P.L. 95-190); of 1979 (P.L.96-63); of 1980 (P.L. 96-502); of 1986 (P.L. 99-339).
3. Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532) as amended by P.L. 94-62 (1975); P.L. 94-326 (1976); P. L. 95-153 (1977); P.L. 96-332 (1980) P.L. 96-381 (1980); P.L. 96-470 (1980); P.L. 97-572 (1980); P.L. 97-16 (1981); P.L. 97-109 (1981); P.L. 97-424 (1983); P.L. 98-498 (1984); P.L. 99-272 (1986); P.L. 100-536, P.L. 100-536, 100-627, 10-688 (1988).

The following is appropriation legislation for the Environmental Protection Agency:

1. Department of Housing and Urban Development - Independent Agencies Appropriations Act, 1980 P.L. 96-103, Supplemental P.L. 96-304; 1981 P.L. 96-526, Supplemental P.L. 97-12; 1982 P.L. 97-101; 1983 P.L. 97-272, Supplemental P.L. 98-63; 1984 P.L. 98-45, Supplemental P.L. 98- 396; 1985 P.L. 98-371, Supplemental P.L. 99-88; 1986 P.L. 99-160; 1987 P.L. 99-500 Supplemental 100-71; 1988 P.L. 100-202; and 1989 P.L. 100-404.

   Note: Not all supplementals listed are related to ground-water; this is a complete list of all supplementals for the 1980 act. Source: Mr. Dennis Devoe, Chief of the Budget Formulation Section, Office of the Controller, Environmental Protection Agency (EPA). Other figures ($ WQ, $ TOTAL, FTE WQ , and FTE TOTAL) were provided by Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

b/ OW: The Office of Water has Underground Injection Control Funds, Pesticide Survey Funds, and Groundwater Protection Program Funds combined with the Water Quality Media Dollars shown in this table.
Sources: Mrs. Jane Ephremides, Chief of the Resources Management & Evaluation Branch, Office of Drinking Water, EPA; and Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

c/ OEA: During the years, 1983-1986, the Office of Wetlands Protection was located under the organizational umbrella, Assistant Administrator for External Affairs. It is now located under the Assistant Administrator for Water.
Source: Mr. Frank Rusincovitch, Senior Budget Officer, Office of External Affairs, EPA.

d/ OARM: Data are no longer available on Water Quality Funds received by the Assistant Administrator for Administration and Resources Management. The 1987 Water Quality figure represents funds reprogramed to the National Computer Center (OARM) by the Office of Water (OW).
To support their environmental programs, the Office of Water purchased expanded ADP capability.
Source: Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

e/ OPPE: The Assistant Administrator for Policy, Planning, and Evaluation (OPPE) receives no appropriated monies in its base program for Water Quality. The Water Quality Funds in the years, 1985-1988, reflect reprogramed dollars for Water Quality projects from the Office of Water.
Officially OPPE has no FTE's appropriated in its base program for Water Quality.
Source: Ms. Mary Free, Executive Officer in the Office of Policy, Planning, and Evaluation, EPA.

TABLE 1 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Water Quality Base Funding for Regions

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
REGION 1 Boston											
$ WQ	11,597.7	12,050.7	9,936.3	9,106.0	9,916.1	11,136.7	11,387.8	12,412.7	27,836.6	12,403.6	
$ TOTAL	28,588.4	32,397.0	31,316.6	30,455.3	35,834.3	56,195.6	47,447.3	106,640.4	131,356.8	90,997.4	
REGION 2 New York											
$ WQ	21,388.3	20,843.0	15,506.8	12,463.9	12,627.4	13,632.3	13,954.4	15,120.3	15,374.7	15,367.7	
$ TOTAL	49,217.7	51,614.0	46,073.0	45,092.8	50,314.4	102,070.2	86,638.9	175,005.4	412,231.6	215,705.2	
REGION 3 Philadelphia											
$ WQ	23,251.8	21,470.5	18,163.4	14,711.8	18,542.3	25,178.7	24,593.7	26,665.3	27,862.2	28,530.0	
$ TOTAL	48,715.6	49,560.1	48,308.3	46,894.5	57,951.2	93,260.9	68,414.3	154,878.4	176,719.0	197,262.2	
REGION 4 Atlanta											
$ WQ	27,956.3	30,251.6	23,524.7	20,086.7	20,264.1	22,347.0	22,726.6	25,075.3	24,112.5	25,437.9	
$ TOTAL	56,085.6	66,191.6	61,939.2	60,951.1	66,508.9	96,850.0	77,839.5	109,845.1	161,182.3	164,523.3	
REGION 5 Chicago											
$ WQ	36,679.9	38,446.9	29,722.5	23,646.0	24,473.8	41,365.8	26,510.4	29,341.6	34,316.8	37,380.7	
$ TOTAL	81,163.0	88,701.6	80,557.2	76,699.1	85,230.9	147,809.3	101,920.6	198,197.1	228,423.0	241,402.3	
REGION 6 Dallas											
$ WQ	17,365.7	18,103.2	13,412.9	13,177.6	13,635.5	15,157.3	14,867.2	16,518.4	17,553.6	17,616.7	
$ TOTAL	41,423.4	45,910.3	44,878.1	45,428.3	48,771.2	68,464.2	66,941.9	93,228.5	132,353.1	158,125.8	
REGION 7 Kansas City											
$ WQ	10,821.5	12,585.5	8,218.4	7,531.5	7,060.0	7,813.9	8,011.7	19,715.5	8,707.8	8,499.1	
$ TOTAL	25,154.9	29,446.5	24,901.3	25,603.6	28,993.1	46,409.9	37,018.9	77,990.5	69,642.7	74,559.6	
REGION 8 Denver											
$ WQ	9,637.1	10,078.2	7,055.8	6,478.8	6,872.4	7,974.8	8,204.4	8,631.5	9,052.0	9,665.1	
$ TOTAL	23,593.2	27,342.8	25,232.8	24,897.8	26,398.0	41,031.6	32,006.9	57,509.4	94,322.7	106,866.5	
REGION 9 San Francisco											
$ WQ	15,169.1	15,631.1	11,411.4	9,443.9	10,046.1	11,631.1	12,148.3	13,092.0	12,909.1	13,421.7	
$ TOTAL	38,627.9	40,516.2	38,484.8	38,538.1	41,141.8	70,526.4	53,856.1	116,845.5	116,024.7	116,656.5	
REGION 10 Seattle											
$ WQ	10,773.8	11,433.4	8,465.1	7,140.1	7,760.4	8,918.4	8,949.1	9,566.1	10,901.7	12,100.1	
$ TOTAL	25,080.1	27,051.9	25,926.2	26,118.0	26,709.3	38,679.1	33,608.1	47,582.0	56,242.7	68,723.9	

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

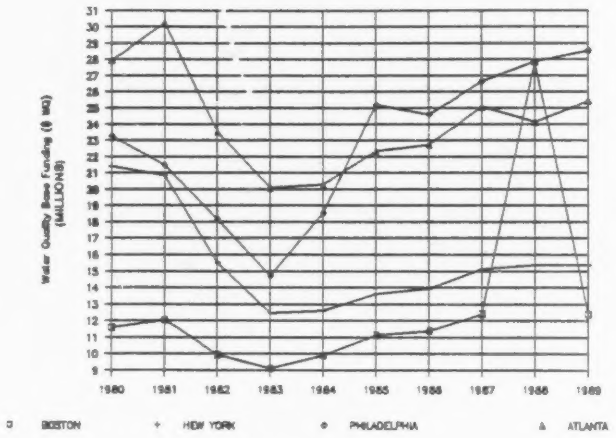
TABLE 1 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

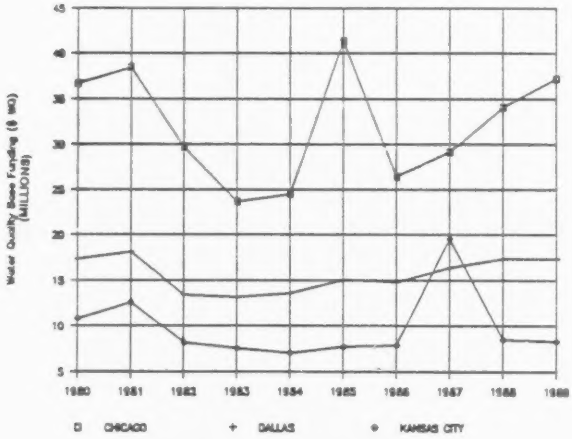
Water Quality Base Funding for Regions

1980-1990

REGIONS: 1, 2, 3, & 4



REGIONS: 5, 6, & 7



REGIONS: 8, 9, & 10

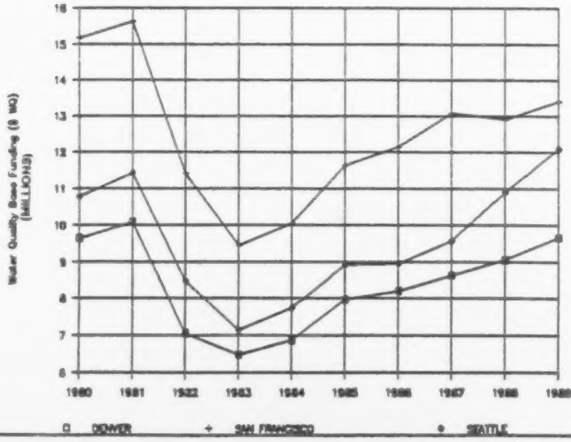


TABLE 2 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Water Quality Levels for Regions

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
1982 GNP Deflator Index Values:	0.855	0.934	1	1.04	1.086	1.123	1.146	1.185	1.237	1.288	1.332
REGION 1 Boston											
$ WQ	13,564.6	12,902.2	9,936.3	8,755.8	9,130.8	9,916.9	9,937.0	10,474.9	22,503.3	9,645.1	
$ TOTAL	33,436.7	34,686.3	31,316.6	29,283.9	32,996.6	50,040.6	41,402.5	89,991.9	106,189.8	70,760.0	
REGION 2 New York											
$ WQ	25,015.6	22,315.8	15,506.8	11,984.5	11,627.4	12,139.2	12,176.6	12,759.7	12,429.0	11,950.0	
$ TOTAL	57,564.6	55,261.2	46,073.0	43,358.5	46,330.0	90,890.7	58,149.1	147,683.9	333,251.1	167,733.4	
REGION 3 Philadelphia											
$ WQ	27,195.1	22,987.7	18,163.4	14,146.0	17,073.9	22,420.9	21,460.5	22,502.4	22,524.0	22,185.1	
$ TOTAL	56,977.3	53,062.2	48,308.3	45,090.9	53,362.1	83,046.2	59,698.3	130,699.1	142,861.0	153,392.1	
REGION 4 Atlanta											
$ WQ	32,697.4	32,389.3	23,524.7	19,314.1	18,659.4	19,899.4	19,831.2	21,160.6	19,492.7	19,780.6	
$ TOTAL	65,597.2	70,869.0	61,939.2	58,606.8	61,242.1	86,242.2	67,922.8	92,696.3	130,301.0	127,934.1	
REGION 5 Chicago											
$ WQ	42,900.5	41,163.7	29,722.5	22,736.5	22,535.7	36,835.1	23,133.0	24,760.8	27,742.0	29,067.4	
$ TOTAL	94,927.5	94,969.6	80,557.2	73,749.1	78,481.5	131,620.0	88,936.0	167,254.9	184,658.9	187,715.6	
REGION 6 Dallas											
$ WQ	20,310.8	19,382.4	13,412.9	12,670.8	12,555.7	13,497.2	12,973.1	13,939.6	14,190.5	13,698.8	
$ TOTAL	48,448.4	49,154.5	44,878.1	43,681.1	44,909.0	60,965.4	58,413.5	78,673.8	106,995.2	122,959.4	
REGION 7 Kansas City											
$ WQ	12,656.7	13,474.8	8,218.4	7,241.8	6,500.9	6,958.1	6,991.0	16,637.6	7,039.5	6,608.9	
$ TOTAL	29,420.9	31,527.3	24,901.3	24,618.8	26,697.1	41,326.7	32,302.7	65,814.8	56,299.7	57,977.9	
REGION 8 Denver											
$ WQ	11,271.5	10,790.4	7,055.8	6,229.6	6,328.2	7,101.3	7,159.2	7,284.0	7,317.7	7,515.6	
$ TOTAL	27,594.4	29,274.9	25,232.8	23,940.2	24,307.6	36,537.5	27,929.2	48,531.1	76,251.2	83,099.9	
REGION 9 San Francisco											
$ WQ	17,741.6	16,735.7	11,411.4	9,080.7	9,250.6	10,357.2	10,600.6	11,048.1	10,435.8	10,436.8	
$ TOTAL	45,178.8	43,379.2	38,484.8	37,055.9	37,883.8	62,801.8	46,994.9	98,603.8	93,795.2	90,712.7	
REGION 10 Seattle											
$ WQ	12,600.9	12,241.3	8,465.1	6,865.5	7,145.9	7,941.6	7,809.0	8,072.7	8,813.0	9,409.1	
$ TOTAL	29,333.5	28,963.5	25,926.2	25,113.5	24,594.2	34,442.7	29,326.4	40,153.6	45,467.0	53,440.0	

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

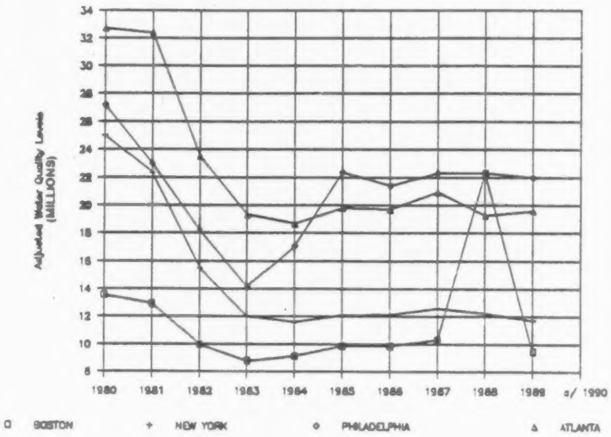
TABLE 2 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

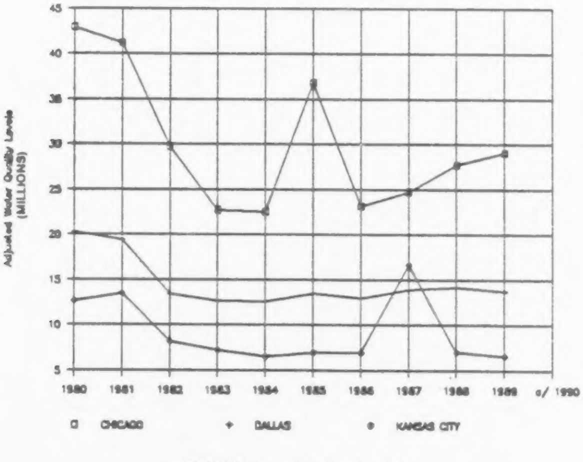
Adjusted Water Quality Levels for Regions

1980–1990

REGIONS: 1, 2, 3, & 4



REGIONS: 5, 6, & 7



REGIONS: 8, 9, & 10

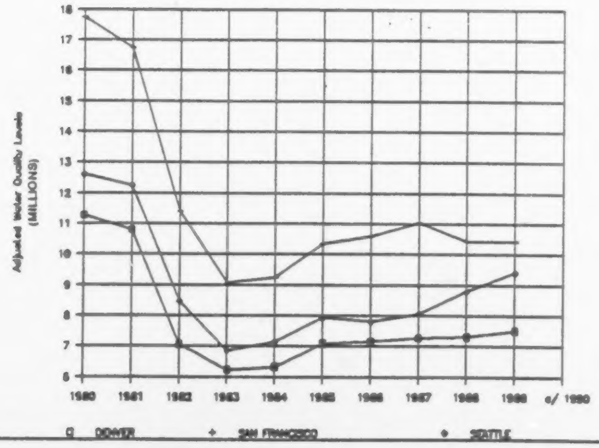


TABLE 3 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Water Quality Personnel Resources for Regions
1980–1990

WQ = Water Quality

FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
REGION 1 Boston											
FTE WQ	176.4	168.1	139.2	113.7	134.8	154.1	155.1	162.1	156.7	157.9	
FTE TOTAL	400.8	405.6	365.3	346.4	396.5	459.3	388.4	502.5	536.4	559.0	
REGION 2 New York											
FTE WQ	301.0	269.0	225.3	154.8	165.9	178.6	177.5	182.9	179.1	172.9	
FTE TOTAL	577.7	561.4	518.4	460.3	513.7	607.4	472.6	697.3	768.7	781.1	
REGION 3 Philadelphia											
FTE WQ	268.2	234.6	225.8	174.4	184.6	197.3	188.3	195.6	193.5	184.4	
FTE TOTAL	568.7	561.9	546.3	499.9	540.7	615.7	497.5	659.8	751.8	767.8	
REGION 4 Atlanta											
FTE WQ	368.1	338.5	280.3	227.3	219.2	231.1	235.8	246.8	246.6	259.5	
FTE TOTAL	698.4	674.5	641.4	574.9	608.0	685.1	592.6	774.9	886.5	905.5	
REGION 5 Chicago											
FTE WQ	413.6	368.3	305.5	240.6	243.9	261.4	264.9	270.8	279.6	271.7	
FTE TOTAL	869.7	865.1	777.2	709.6	795.4	913.0	786.4	1,013.0	1,130.1	1,154.2	
REGION 6 Dallas											
FTE WQ	241.7	225.0	211.7	187.0	199.3	214.5	209.0	221.3	231.7	227.9	
FTE TOTAL	509.0	501.9	508.5	473.7	520.1	602.9	530.5	691.3	754.5	751.7	
REGION 7 Kansas City											
FTE WQ	164.4	156.7	121.3	98.8	96.9	101.9	100.6	103.7	96.8	99.2	
FTE TOTAL	368.3	387.6	335.3	317.0	335.8	370.6	305.6	402.1	447.8	471.9	
REGION 8 Denver											
FTE WQ	135.4	128.2	110.3	102.0	101.4	104.8	103.8	108.7	109.1	111.5	
FTE TOTAL	348.6	374.8	352.4	329.4	323.4	352.6	316.1	403.6	446.5	460.3	
REGION 9 San Francisco											
FTE WQ	146.4	143.6	128.0	105.4	119.6	130.2	133.7	139.4	135.8	138.7	
FTE TOTAL	391.8	394.2	375.6	372.8	401.3	460.0	415.1	529.0	576.0	624.0	
REGION 10 Seattle											
FTE WQ	138.6	127.8	123.8	107.0	113.1	128.2	124.0	130.5	129.7	130.6	
FTE TOTAL	329.0	347.0	323.0	298.3	308.0	363.9	314.7	387.8	419.2	447.5	

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

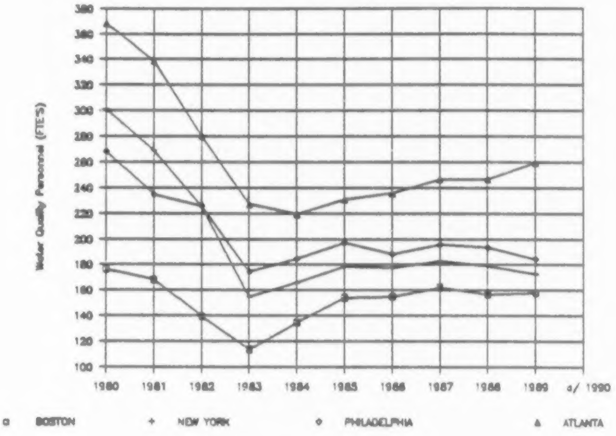
TABLE 3 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

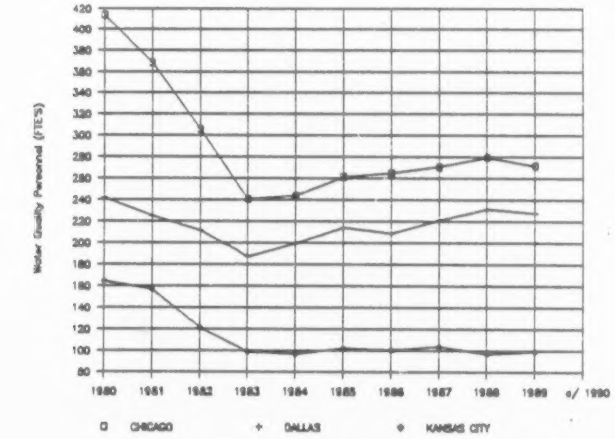
Water Quality Personnel Resources for Regions

1980–1990

REGIONS: 1, 2, 3, & 4



REGIONS: 5, 6, & 7



REGIONS: 8, 9, & 10

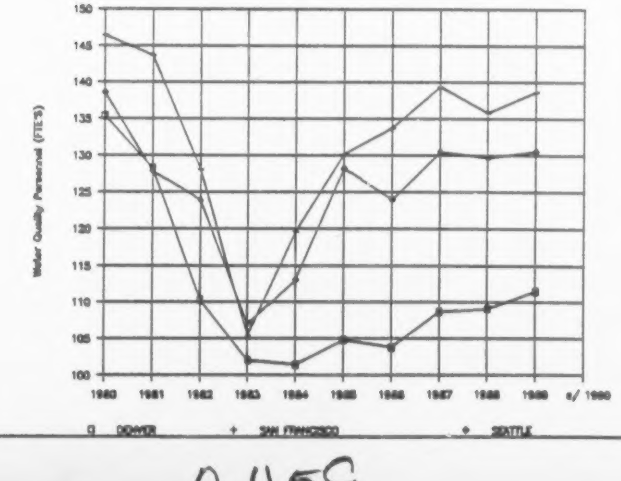


TABLE 4 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Adjusted Funding Directed to Water Quality for Regions

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
REGION 1 Boston											
$ WQ	13,564.6	12,902.2	9,936.3	8,755.8	9,130.8	9,916.9	9,937.0	10,474.9	22,503.3	9,645.1	
$ TOTAL	33,436.7	34,686.3	31,316.6	29,283.9	32,996.6	50,040.6	41,402.5	89,991.9	106,189.8	70,760.0	
$ WQ/$ TOTAL (%)	**40.6**	**37.2**	**31.7**	**29.9**	**27.7**	**19.8**	**24.0**	**11.6**	**21.2**	**13.6**	
REGION 2 New York											
$ WQ	25,015.6	22,315.8	15,506.8	11,984.5	11,627.4	12,139.2	12,176.6	12,759.7	12,429.0	11,950.0	
$ TOTAL	57,564.6	55,261.2	46,073.0	43,358.5	46,330.0	90,880.7	58,149.1	147,683.9	333,251.1	167,733.4	
$ WQ/$ TOTAL (%)	**43.5**	**40.4**	**33.7**	**27.6**	**25.1**	**13.4**	**20.9**	**8.6**	**3.7**	**7.1**	
REGION 3 Philadelphia											
$ WQ	27,195.1	22,987.7	18,163.4	14,146.0	17,073.9	22,420.9	21,460.5	22,502.4	22,524.0	22,185.1	
$ TOTAL	56,977.3	53,062.2	48,308.3	45,090.9	53,362.1	83,046.2	59,698.3	130,699.1	142,861.0	153,392.1	
$ WQ/$ TOTAL (%)	**47.7**	**43.3**	**37.6**	**31.4**	**32.0**	**27.0**	**35.9**	**17.2**	**15.8**	**14.5**	
REGION 4 Atlanta											
$ WQ	32,697.4	32,389.3	23,524.7	19,314.1	18,659.4	19,899.4	19,831.2	21,160.6	19,492.7	19,780.6	
$ TOTAL	65,597.2	70,869.0	61,939.2	58,606.8	61,242.1	86,242.2	67,922.8	92,696.3	130,301.0	127,934.1	
$ WQ/$ TOTAL (%)	**49.8**	**45.7**	**38.0**	**33.0**	**30.5**	**23.1**	**29.2**	**22.8**	**15.0**	**15.5**	
REGION 5 Chicago											
$ WQ	42,900.5	41,163.7	29,722.5	22,736.5	22,535.7	36,835.1	23,133.0	24,760.8	27,742.0	29,067.4	
$ TOTAL	94,927.5	94,969.6	80,557.2	73,749.1	78,481.5	131,620.0	88,936.0	167,254.9	184,658.9	187,715.6	
$ WQ/$ TOTAL (%)	**45.2**	**43.3**	**36.9**	**30.8**	**28.7**	**28.0**	**26.0**	**14.8**	**15.0**	**15.5**	
REGION 6 Dallas											
$ WQ	20,310.8	19,382.4	13,412.9	12,670.8	12,555.7	13,497.2	12,973.1	13,939.6	14,190.5	13,698.8	
$ TOTAL	48,448.4	49,154.5	44,878.1	43,681.1	44,909.0	60,965.4	58,413.5	78,673.8	106,995.2	122,959.4	
$ WQ/$ TOTAL (%)	**41.9**	**39.4**	**29.9**	**29.0**	**28.0**	**22.1**	**22.2**	**17.7**	**13.3**	**11.1**	
REGION 7 Kansas City											
$ WQ	12,656.7	13,474.8	8,218.4	7,241.8	6,500.9	6,958.1	6,991.0	16,637.6	7,039.5	6,608.9	
$ TOTAL	29,420.9	31,527.3	24,901.3	24,618.8	26,697.1	41,326.7	32,302.7	65,814.8	56,299.7	57,977.9	
$ WQ/$ TOTAL (%)	**43.0**	**42.7**	**33.0**	**29.4**	**24.4**	**16.8**	**21.6**	**25.3**	**12.5**	**11.4**	
REGION 8 Denver											
$ WQ	11,271.5	10,790.4	7,055.8	6,229.6	6,328.2	7,101.3	7,159.2	7,284.0	7,317.7	7,515.6	
$ TOTAL	27,594.4	29,274.9	25,232.8	23,940.2	24,307.6	36,537.5	27,929.2	48,531.1	76,251.2	83,099.9	
$ WQ/$ TOTAL (%)	**40.8**	**36.9**	**28.0**	**26.0**	**26.0**	**19.4**	**25.6**	**15.0**	**9.6**	**9.0**	
REGION 9 San Francisco											
$ WQ	17,741.6	16,735.7	11,411.4	9,080.7	9,250.6	10,357.2	10,600.6	11,048.1	10,435.8	10,436.8	
$ TOTAL	45,178.8	43,379.2	38,484.8	37,055.9	37,883.8	62,801.8	46,994.9	98,603.8	93,795.2	90,712.7	
$ WQ/$ TOTAL (%)	**39.3**	**38.6**	**29.7**	**24.5**	**24.4**	**16.5**	**22.6**	**11.2**	**11.1**	**11.5**	
REGION 10 Seattle											
$ WQ	12,600.9	12,241.3	8,465.1	6,865.5	7,145.9	7,941.6	7,809.0	8,072.7	8,813.0	9,409.1	
$ TOTAL	29,333.5	28,963.5	25,926.2	25,113.5	24,594.2	34,442.7	29,326.4	40,153.6	45,467.0	53,440.0	
$ WQ/$ TOTAL (%)	**43.0**	**42.3**	**32.7**	**27.3**	**29.1**	**23.1**	**26.6**	**20.1**	**19.4**	**17.6**	

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

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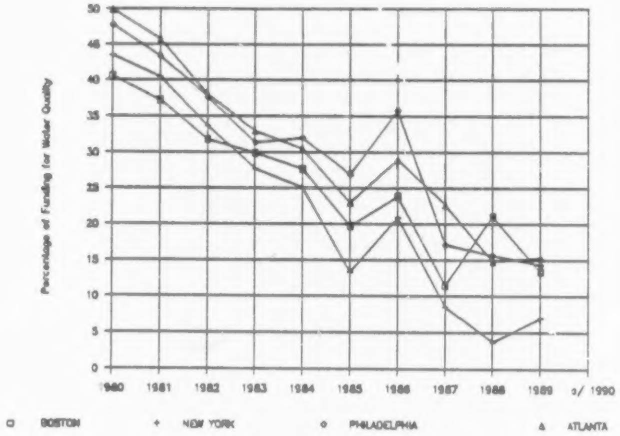
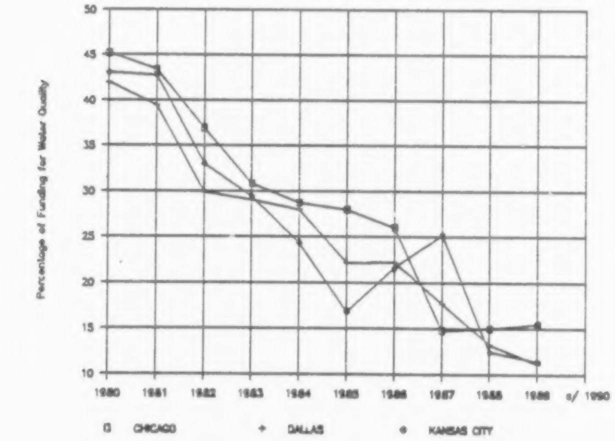
TABLE 4 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Adjusted Funding Directed to Water Quality for Regions

1980–1990


REGIONS: 1, 2, 3, & 4


REGIONS: 5, 6, & 7

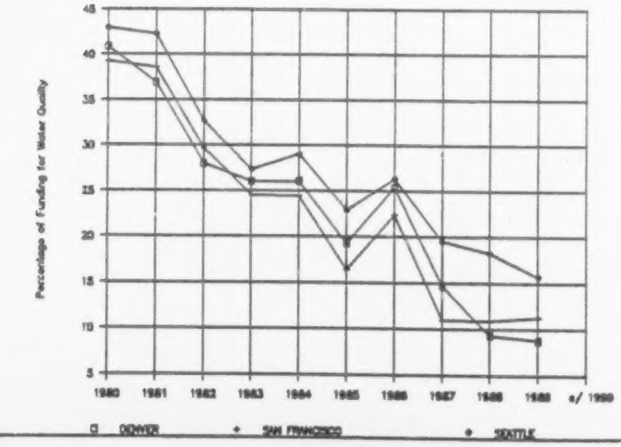

REGIONS: 8, 9, & 10

TABLE 5 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Total Personnel Assigned to Water Quality for Regions

1980–1990

WQ = Water Quality

FTE = Full-Time Equivalent

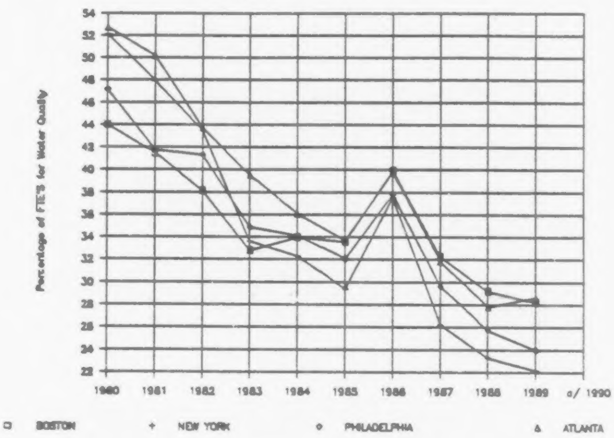
YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
REGION 1 Boston											
FTE WQ	176.4	168.1	139.2	113.7	134.8	154.1	155.1	162.1	156.7	157.9	
FTE TOTAL	400.8	405.6	365.3	346.4	396.5	459.3	388.4	502.5	536.4	559.0	
FTE WQ/FTE TOTAL (%)	44.0	41.4	38.1	32.8	34.0	33.6	39.9	32.3	29.2	28.2	
REGION 2 New York											
FTE WQ	301.0	269.0	225.3	154.8	165.9	178.6	177.5	182.9	179.1	172.9	
FTE TOTAL	577.7	561.4	518.4	460.3	513.7	607.4	472.6	697.3	768.7	781.1	
FTE WQ/FTE TOTAL (%)	52.1	47.9	43.5	33.6	32.3	29.4	37.6	26.2	23.3	22.1	
REGION 3 Philadelphia											
FTE WQ	268.2	234.6	225.8	174.4	184.6	197.3	188.3	195.6	193.5	184.4	
FTE TOTAL	568.7	561.9	546.3	499.9	540.7	615.7	497.5	659.8	751.8	767.8	
FTE WQ/FTE TOTAL (%)	47.2	41.8	41.3	34.9	34.1	32.0	37.8	29.6	25.7	24.0	
REGION 4 Atlanta											
FTE WQ	368.1	338.5	280.3	227.3	219.2	231.1	235.8	246.8	246.6	259.5	
FTE TOTAL	698.4	674.5	641.4	574.9	608.0	685.1	592.6	774.9	886.5	905.5	
FTE WQ/FTE TOTAL (%)	52.7	50.2	43.7	39.5	36.1	33.7	39.8	31.8	27.8	28.7	
REGION 5 Chicago											
FTE WQ	413.6	368.3	305.5	240.6	243.9	261.4	264.9	270.8	279.6	271.7	
FTE TOTAL	869.7	865.1	777.2	709.6	795.4	913.0	786.4	1,013.0	1,130.1	1,154.2	
FTE WQ/FTE TOTAL (%)	47.6	42.6	39.3	33.9	30.7	28.6	33.7	26.7	24.7	23.5	
REGION 6 Dallas											
FTE WQ	241.7	225.0	211.7	187.0	199.3	214.5	209.0	221.3	231.7	227.9	
FTE TOTAL	509.0	501.9	508.5	473.7	520.1	602.9	530.5	691.3	754.5	751.7	
FTE WQ/FTE TOTAL (%)	47.5	44.8	41.6	39.5	38.3	35.6	39.4	32.0	30.7	30.3	
REGION 7 Kansas City											
FTE WQ	164.4	156.7	121.3	98.8	96.9	101.9	100.6	103.7	96.8	99.2	
FTE TOTAL	368.3	387.6	335.3	317.0	335.8	370.6	305.6	402.1	447.8	471.9	
FTE WQ/FTE TOTAL (%)	44.6	40.4	36.2	31.2	28.9	27.5	32.9	25.8	21.6	21.0	
REGION 8 Denver											
FTE WQ	135.4	128.2	110.3	102.0	101.4	104.8	103.8	108.7	109.1	111.5	
FTE TOTAL	348.6	374.8	352.4	329.4	323.4	352.6	316.1	403.6	446.5	460.3	
FTE WQ/FTE TOTAL (%)	38.8	34.2	31.3	31.0	31.4	29.7	32.8	26.9	24.4	24.2	
REGION 9 San Francisco											
FTE WQ	146.4	143.6	128.0	105.4	119.6	130.2	133.7	139.4	135.8	138.7	
FTE TOTAL	391.8	394.2	375.6	372.8	401.3	460.0	415.1	529.0	576.0	624.0	
FTE WQ/FTE TOTAL (%)	37.4	36.4	34.1	28.3	29.8	28.3	32.2	26.4	23.6	22.2	
REGION 10 Seattle											
FTE WQ	138.6	127.8	123.8	107.0	113.1	128.2	124.0	130.5	129.7	130.6	
FTE TOTAL	329.0	347.0	323.0	298.3	308.0	363.9	314.7	387.8	419.2	447.5	
FTE WQ/FTE TOTAL (%)	42.1	36.8	38.3	35.9	36.7	35.2	39.4	33.7	30.9	29.2	

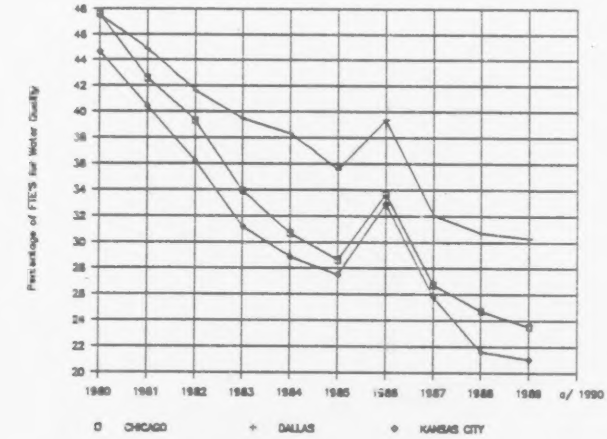
** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

TABLE 5 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Percentage of Total Personnel Assigned to Water Quality for Regions
1980–1990


REGIONS: 1, 2, 3, & 4


REGIONS: 5, 6, & 7

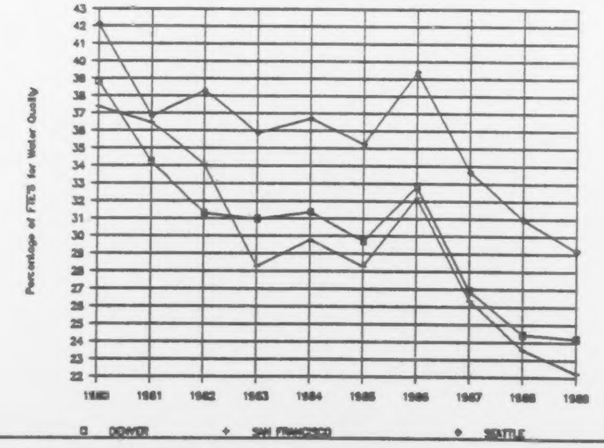

REGIONS: 8, 9, & 10

TABLE 6 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Regions

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
REGION 1 Boston											
$ WQ	13,564.6	12,902.2	9,936.3	8,755.8	9,130.8	9,916.9	9,937.0	10,474.9	22,503.3	9,645.1	
FTE WQ	176.4	168.1	139.2	113.7	134.8	154.1	155.1	162.1	156.7	157.9	
$ WQ/FTE WQ	**76.9**	**76.8**	**71.4**	**77.0**	**67.7**	**64.4**	**64.1**	**64.6**	**143.6**	**61.1**	
REGION 2 New York											
$ WQ	25,015.6	22,315.8	15,506.8	11,984.5	11,627.4	12,139.2	12,176.6	12,759.7	12,429.0	11,950.0	
FTE WQ	301.0	269.0	225.3	154.8	165.9	178.6	177.5	182.9	179.1	172.9	
$ WQ/FTE WQ	**83.1**	**83.0**	**68.8**	**77.4**	**70.1**	**68.0**	**68.6**	**69.8**	**69.4**	**69.1**	
REGION 3 Philadelphia											
$ WQ	27,195.1	22,987.7	18,163.4	14,146.0	17,073.9	22,420.9	21,460.5	22,502.4	22,524.0	22,185.1	
FTE WQ	268.2	234.6	225.8	174.4	184.6	197.3	188.3	195.6	193.5	184.4	
$ WQ/FTE WQ	**101.4**	**98.0**	**80.4**	**81.1**	**92.5**	**113.6**	**114.0**	**115.0**	**116.4**	**120.3**	
REGION 4 Atlanta											
$ WQ	32,697.4	32,389.3	23,524.7	19,314.1	18,659.4	19,899.4	19,831.2	21,160.6	19,492.7	19,780.6	
FTE WQ	368.1	338.5	280.3	227.3	219.2	231.1	235.8	246.8	246.6	259.5	
$ WQ/FTE WQ	**88.8**	**95.7**	**83.9**	**85.0**	**85.1**	**86.1**	**84.1**	**85.7**	**79.0**	**76.2**	
REGION 5 Chicago											
$ WQ	42,900.5	41,163.7	29,722.5	22,736.5	22,535.7	36,835.1	23,133.0	24,760.8	27,742.0	29,067.4	
FTE WQ	413.6	368.3	305.5	240.6	243.9	261.4	264.9	270.8	279.6	271.7	
$ WQ/FTE WQ	**103.7**	**111.8**	**97.3**	**94.5**	**92.4**	**140.9**	**87.3**	**91.4**	**99.2**	**107.0**	
REGION 6 Dallas											
$ WQ	20,310.8	19,382.4	13,412.9	12,670.8	12,555.7	13,497.2	12,973.1	13,939.6	14,190.5	13,698.8	
FTE WQ	241.7	225.0	211.7	187.0	199.3	214.5	209.0	221.3	231.7	227.9	
$ WQ/FTE WQ	**84.0**	**86.1**	**63.4**	**67.8**	**63.0**	**62.9**	**62.1**	**63.0**	**61.2**	**60.1**	
REGION 7 Kansas City											
$ WQ	12,656.7	13,474.8	8,218.4	7,241.8	6,500.9	6,958.1	6,991.0	16,637.6	7,039.5	6,608.[illegible]	
FTE WQ	164.4	156.7	121.3	98.8	96.9	101.9	100.6	103.7	96.8	99.2	
$ WQ/FTE WQ	**77.0**	**86.0**	**67.8**	**73.3**	**67.1**	**68.3**	**69.5**	**160.4**	**72.7**	**66.6**	
REGION 8 Denver											
$ WQ	11,271.5	10,790.4	7,055.8	6,229.6	6,328.2	7,101.3	7,159.2	7,284.0	7,317.7	7,515.6	
FTE WQ	135.4	128.2	110.3	102.0	101.4	104.8	103.8	108.7	109.1	111.5	
$ WQ/FTE WQ	**83.2**	**84.2**	**64.0**	**61.1**	**62.4**	**67.8**	**69.0**	**67.0**	**67.1**	**67.4**	
REGION 9 San Francisco											
$ WQ	17,741.6	16,735.7	11,411.4	9,080.7	9,250.6	10,357.2	10,600.6	11,048.1	10,435.8	10,436.8	
FTE WQ	146.4	143.6	128.0	105.4	119.6	130.2	133.7	139.4	135.8	138.7	
$ WQ/FTE WQ	**121.2**	**116.5**	**89.2**	**86.2**	**77.3**	**79.5**	**79.3**	**79.3**	**76.8**	**75.2**	
REGION 10 Seattle											
$ WQ	12,600.9	12,241.3	8,465.1	6,865.5	7,145.9	7,941.6	7,809.0	8,072.7	8,813.0	9,409.1	
FTE WQ	138.6	127.8	123.8	107.0	113.1	128.2	124.0	130.5	129.7	130.6	
$ WQ/FTE WQ	**90.9**	**95.8**	**68.4**	**64.2**	**63.2**	**61.9**	**63.0**	**61.9**	**67.9**	**72.0**	

** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

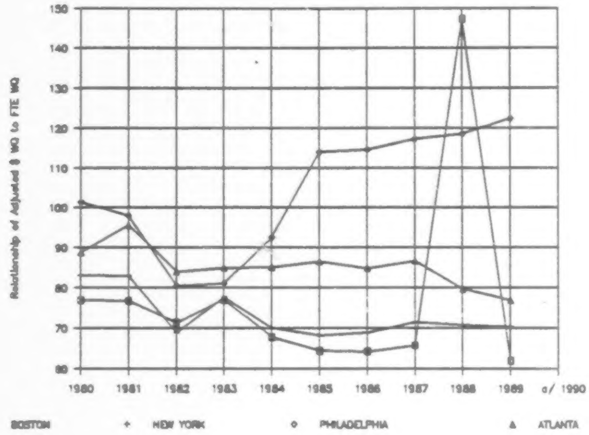
TABLE 6 GRAPHS:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

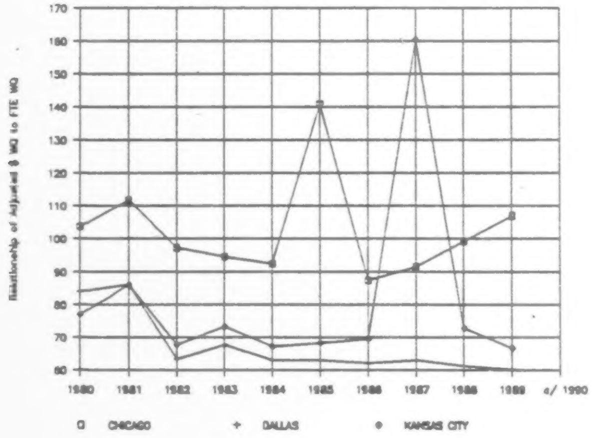
Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality for Regions

1980–1990

REGIONS: 1, 2, 3, & 4



REGIONS: 5, 6, & 7



REGIONS: 8, 9, & 10

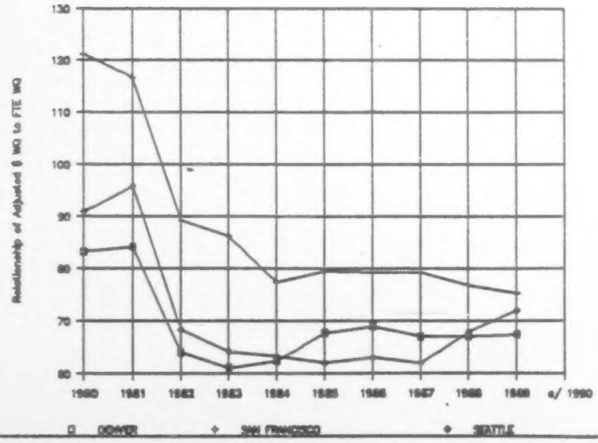


TABLE 7 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Relationship of Adjusted Total Funding to Total Personnel for Regions

1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds   FTE = Full-Time Equivalent

YEAR:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
REGION 1 Boston											a/
$ TOTAL	33,438.7	34,686.3	31,316.6	29,283.9	32,996.6	50,040.6	41,402.5	89,991.9	106,189.8	70,760.0	
FTE TOTAL	400.8	405.6	365.3	346.4	396.5	459.3	388.4	502.5	536.4	559.0	
$ TOTAL/FTE TOTAL	**83.4**	**85.5**	**85.7**	**84.5**	**83.2**	**108.9**	**106.6**	**179.1**	**198.0**	**126.6**	
REGION 2 New York											
$ TOTAL	57,564.6	55,261.2	46,073.0	43,358.5	46,330.0	90,890.7	58,149.1	147,683.9	333,251.1	167,733.4	
FTE TOTAL	577.7	561.4	518.4	460.3	513.7	607.4	472.6	697.3	768.7	781.1	
$ TOTAL/FTE TOTAL	**99.6**	**98.4**	**88.9**	**94.2**	**90.2**	**149.6**	**123.0**	**211.8**	**433.5**	**214.7**	
REGION 3 Philadelphia											
$ TOTAL	56,977.3	53,062.2	48,308.3	45,090.9	53,362.1	83,046.2	59,698.3	130,699.1	142,861.0	153,392.1	
FTE TOTAL	568.7	561.9	546.3	499.9	540.7	615.7	497.5	659.8	751.8	767.8	
$ TOTAL/FTE TOTAL	**100.2**	**94.4**	**88.4**	**90.2**	**98.7**	**134.9**	**120.0**	**198.1**	**190.0**	**199.8**	
REGION 4 Atlanta											
$ TOTAL	65,597.2	70,869.0	61,939.2	58,606.8	61,242.1	86,242.2	67,922.8	92,696.3	130,301.0	127,934.1	
FTE TOTAL	698.4	674.5	641.4	574.9	608.0	685.1	592.6	774.9	886.5	905.5	
$ TOTAL/FTE TOTAL	**93.9**	**105.1**	**96.6**	**101.9**	**100.7**	**125.9**	**114.6**	**119.6**	**147.0**	**141.3**	
REGION 5 Chicago											
$ TOTAL	94,927.5	94,969.6	80,557.2	73,749.1	78,481.5	131,620.0	88,936.0	167,254.9	184,658.9	187,715.6	
FTE TOTAL	869.7	865.1	777.2	709.6	795.4	913.0	786.4	1,013.0	1,130.1	1,154.2	
$ TOTAL/FTE TOTAL	**109.1**	**109.8**	**103.7**	**103.9**	**98.7**	**144.2**	**113.1**	**165.1**	**163.4**	**162.6**	
REGION 6 Dallas											
$ TOTAL	48,448.4	49,154.5	44,878.1	43,681.1	44,909.0	60,965.4	58,413.5	78,673.8	106,995.2	122,959.4	
FTE TOTAL	509.0	501.9	508.5	473.7	520.1	602.9	530.5	691.3	754.5	751.7	
$ TOTAL/FTE TOTAL	**95.2**	**97.9**	**88.3**	**92.2**	**86.3**	**101.1**	**110.1**	**113.8**	**141.8**	**163.6**	
REGION 7 Kansas City											
$ TOTAL	29,420.9	31,527.3	24,901.3	24,618.8	26,697.1	41,326.7	32,302.7	65,814.8	56,299.7	57,977.9	
FTE TOTAL	368.3	387.6	335.3	317.0	335.8	370.6	305.6	402.1	447.8	471.9	
$ TOTAL/FTE TOTAL	**79.9**	**81.3**	**74.3**	**77.7**	**79.5**	**111.5**	**105.7**	**163.7**	**125.7**	**122.9**	
REGION 8 Denver											
$ TOTAL	27,594.4	29,274.9	25,232.8	23,940.2	24,307.6	36,537.5	27,929.2	48,531.1	76,251.2	83,099.9	
FTE TOTAL	348.6	374.8	352.4	329.4	323.4	352.6	316.1	403.6	446.5	460.3	
$ TOTAL/FTE TOTAL	**79.2**	**78.1**	**71.6**	**72.7**	**75.2**	**103.6**	**88.4**	**120.2**	**170.8**	**180.5**	
REGION 9 San Francisco											
$ TOTAL	45,178.8	43,379.2	38,484.8	37,055.9	37,883.8	62,801.8	46,994.9	98,603.8	93,795.2	90,712.7	
FTE TOTAL	391.8	394.2	375.6	372.8	401.3	460.0	415.1	529.0	576.0	624.0	
$ TOTAL/FTE TOTAL	**115.3**	**110.0**	**102.5**	**99.4**	**94.4**	**136.5**	**113.2**	**186.4**	**162.8**	**145.4**	
REGION 10 Seattle											
$ TOTAL	29,333.5	28,963.5	25,926.2	25,113.5	24,594.2	34,442.7	29,326.4	40,153.6	45,467.0	53,440.0	
FTE TOTAL	329.0	347.0	323.0	298.3	308.0	363.9	314.7	387.8	419.2	447.5	
$ TOTAL/FTE TOTAL	**89.2**	**83.5**	**80.3**	**84.2**	**79.9**	**94.6**	**93.2**	**103.5**	**108.5**	**119.4**	

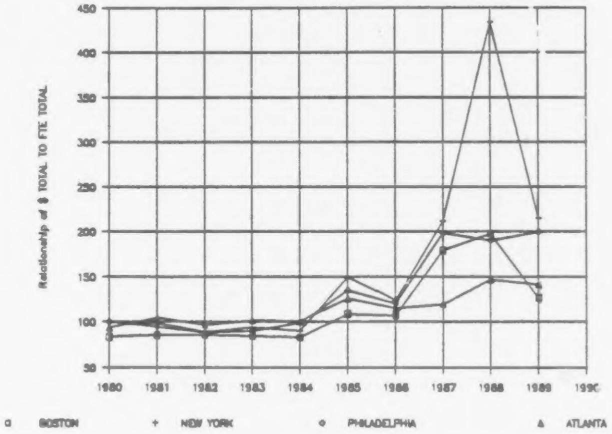
** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

TABLE 7 OF 8:

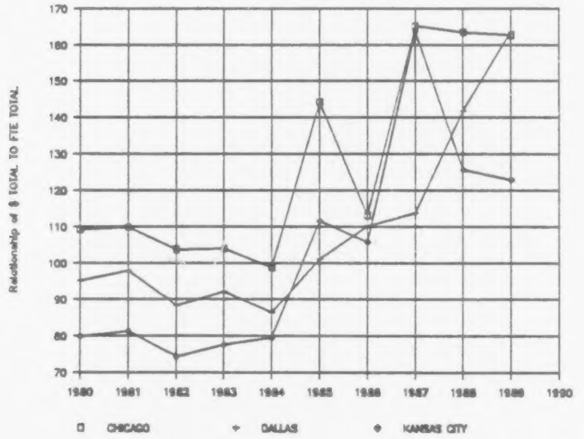
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Relationship of Adjusted Total Funding to Total Personnel for Regions
1980–1990

REGIONS: 1, 2, 3, & 4



REGIONS: 5, 6, & 7



REGIONS: 8, 9, & 10

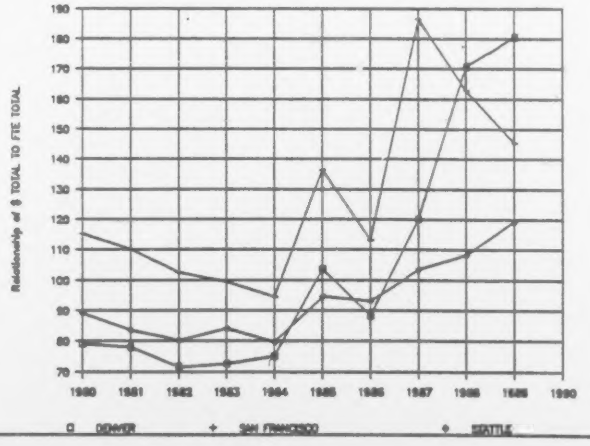


TABLE 8 OF 8:

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Regions

1980–1990

WQ = Water Quality

$ = Appropriated Funds

FTE = Full-Time Equivalent

YEAR:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	a/ 1990
REGION 1 Boston	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.9	0.9	0.8	0.9	0.8	0.6	0.6	0.4	0.7	0.5	
REGION 2 New York	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.8	0.8	0.8	0.8	0.8	0.5	0.6	0.3	0.2	0.3	
REGION 3 Philadelphia	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	1.0	0.9	0.9	0.9	0.8	0.9	0.6	0.6	0.6	
REGION 4 Atlanta	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.9	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.5	0.5	
REGION 5 Chicago	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	1.0	0.9	0.9	0.9	1.0	0.8	0.6	0.6	0.7	
REGION 6 Dallas	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	0.9	0.9	0.7	0.7	0.7	0.6	0.6	0.6	0.4	0.4	
REGION 7 Kansas City	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	1.1	0.9	0.9	0.8	0.6	0.7	1.0	0.6	0.5	
REGION 8 Denver	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.1	1.1	0.9	0.8	0.8	0.7	0.8	0.6	0.4	0.4	
REGION 9 San Francisco	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.1	1.1	0.9	0.9	0.8	0.6	0.7	0.4	0.5	0.5	
REGION 10 Seattle	$ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	1.1	0.9	0.8	0.8	0.7	0.7	0.6	0.6	0.6	

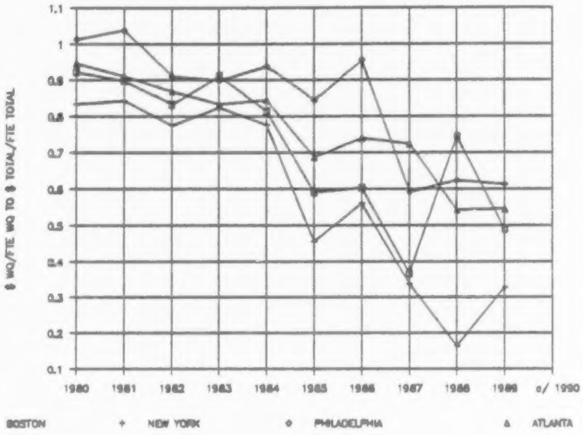
** NOTE: FOOTNOTES FOR TABLES 1–8 FOLLOW TABLE 8.

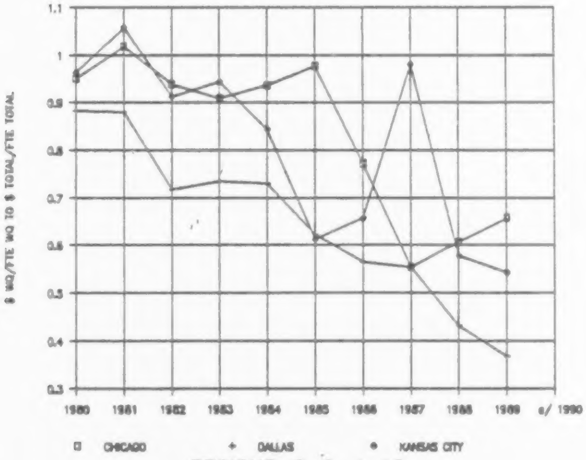
TABLE 8 GRAPHS:

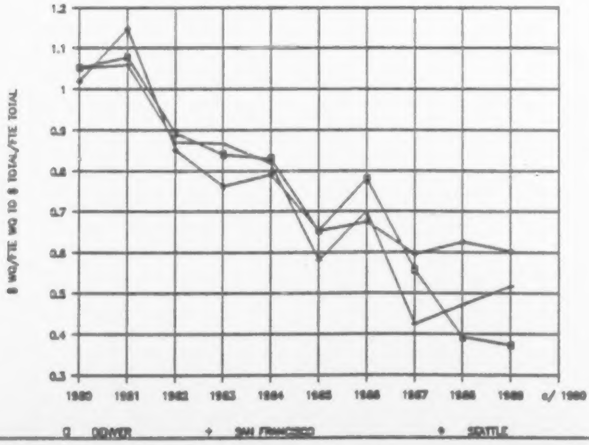
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person for Regions

1980–1990


REGIONS: 1, 2, 3, & 4


REGIONS: 5, 6, & 7


REGIONS: 8, 9, & 10

FOOTNOTES

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY'S REGIONAL OFFICES' TABLES 1–8:

* Note: No overlap in appropriated funding exists between the administrators' and the regional offices' tables.

a/ The regional breakdowns of the President's FY 1990 Budget Request does not become available until the appeals process is completed in late 1989.

The following is authorizing legislation for the Environmental Protection Agency in the area of ground-water:

1. Federal Water Pollution Control Act of 1972 (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-217) as amended by the Water Quality Act of 1987 (P.L. 100-4).
2. The Safe Drinking Act of 1974 (P.L. 93-523); the Safe Drinking Water amendments of 1977 (P.L. 95-190); of 1979 (P.L.96-63); of 1980 (P.L. 96-502); of 1986 (P.L. 99-339).
3. Marine Protection, Research, and Sanctuaries Act of 1972 (P.L. 92-532) as amended by P.L. 94-62 (1975); P.L. 94-326 (1976); P. L. 95-153 (1977); P.L. 96-332 (1980) P.L. 96-381 (1980); P.L. 96-470 (1980); P.L. 97-572 (1980); P.L. 97-16 (1981); P.L. 97-109 (1981); P.L. 97-424 (1983); P.L. 98-498 (1984); P.L. 99-272 (1986); P.L. 100-536, P.L. 100-536, 100-627, 10-688 (1988).

The following is appropriation legislation for the Environmental Protection Agency:

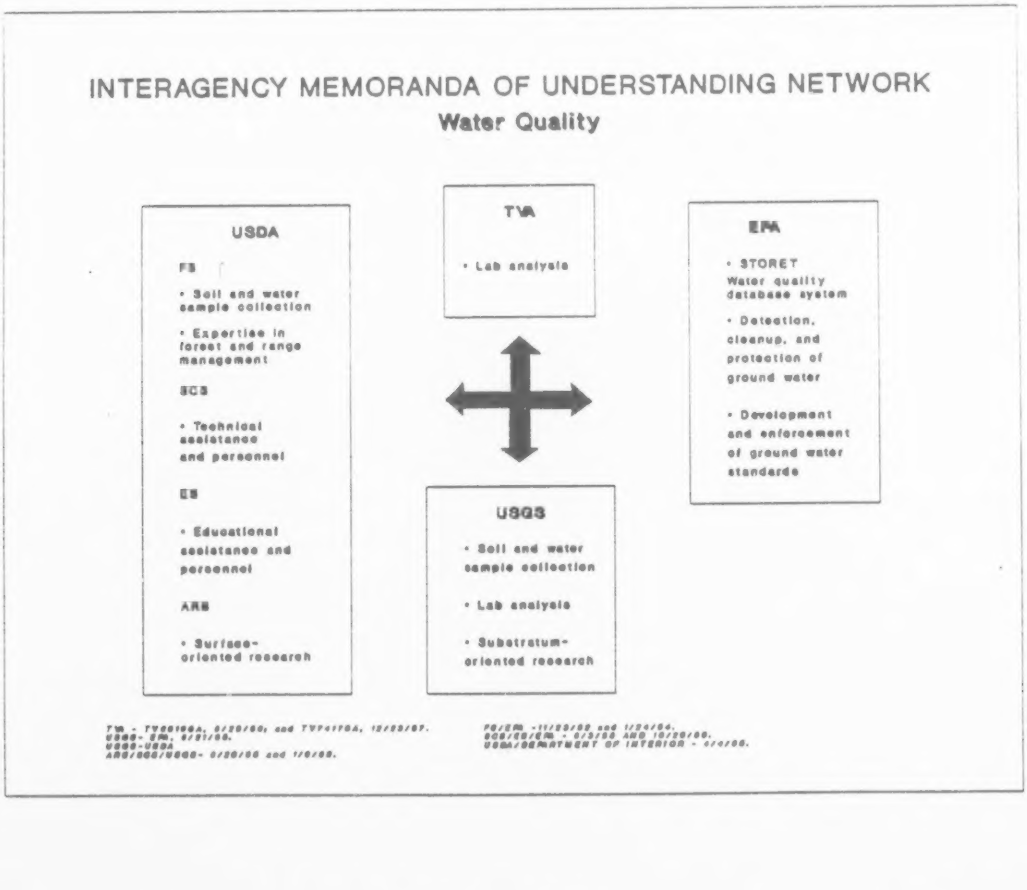
1. Department of Housing and Urban Development - Independent Agencies Appropriations Act, 1980 P.L. 96-103, Supplemental P.L. 96-304; 1981 P.L. 96-526, Supplemental P.L. 97-12; 1982 P.L. 97-101; 1983 P.L. 97-272, Supplemental P.L. 98-63; 1984 P.L. 98-45, Supplemental P.L. 98- 396; 1985 P.L. 98-371, Supplemental P.L. 99-88; 1986 P.L. 99-160; 1987 P.L. 99-500 Supplemental 100-71; 1988 P.L. 100-202; and 1989 P.L. 100-404.

   Note: Not all supplementals listed are related to ground-water; this is a complete list of all supplementals for the 1980 act. Source: Mr. Dennis Devoe, Chief of the Budget Formulation Section, Office of the Controller, Environmental Protection Agency (EPA). Other figures (\$ WQ, \$ TOTAL, FTE WQ , and FTE TOTAL) were provided by Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

APPENDIX G: WATER-QUALITY MEMORANDA NETWORK AND FEDERAL AGENCIES WATER-QUALITY TABLES

Because ground water is a comprehensive issue requiring multiagency involvement, extensive coordination among the Federal agencies must and does occur. As a consequence, the Federal agencies have developed an intricate memoranda network to address the complexities involved in protecting the Nation's ground water (Figure 12).

Figure 12:


INTERAGENCY MEMORANDA OF UNDERSTANDING NETWORK
Water Quality
USDA
FS
• Soil and water sample collection
• Expertise in forest and range management
SCS
• Technical assistance and personnel
ES
• Educational assistance and personnel
ARS
• Surface-oriented research
TVA
• Lab analysis
USGS
• Soil and water sample collection
• Lab analysis
• Substratum-oriented research
EPA
• STORET Water quality database system
• Detection, cleanup, and protection of ground water
• Development and enforcement of ground water standards

TVA-USGS/TVA-FS/TVA-USACE/FS-EPA

In January 1986, the Tennessee Valley Authority and the United States Geological Survey signed an interagency agreement to form a coordination committee to communicate and coordinate surface- and ground-water data. With this agreement, TVA performed the lab analyses and USGS collected the environmental water samples.

A similar agreement was signed between TVA and the Forest Service in December, 1987. Forest Service personnel collected soil and water samples from the Eastern Region of the National Forest System. TVA provided the soil and water laboratory analyses, and resultant data were then stored in the Environmental Protection Agency's STORET water-quality database system.

Additionally, TVA provides laboratory analyses of nonpoint source discharges for the military districts of the U. S. Army Corps of Engineers.

SCS-ES-EPA

The Environmental Protection Agency and the United States Department of Agriculture have an agreement whereby the USDA--through its Soil Conservation Service and Extension Service--provides technical and educational expertise for the development of groundwater protection literature. The literature is to be distributed at the county level.

ARS-SCS-USGS

To obtain a more comprehensive understanding of soil and water dynamics, the Agricultural Research Service, Soil Conservation Service, and the United States Geological Survey entered into a cooperative research agreement. On selected sites, ARS provides surface-oriented research, USGS provides substratum-oriented research, and SCS provides the technical link between the agencies.

EPA-ASCS-ERS-SCS-FS-ARS

In September, 1986 the Environmental Protection Agency, the Agricultural Stabilization and Conservation Service, Economic Research Service, Soil Conservation Service, Forest Service and Agricultural Research Service signed a cooperative agreement with the North Carolina Extension Service to develop an agricultural/water-quality database and data-management system. Drawing of the resources and expertise of the various agencies to build the system, the database was to act as a nonpoint-source clearing-house and information center for state and federal agencies, and the private sector. The national database is operational at the North Carolina Extension Service; however, lack of funding and personnel resources prevent possible clearing-house activities.

U. S. Federal Agencies Water Quality Tables

To derive a sum-total of federal spending on and personnel allocated to water-quality, the tables entitled, **United States Federal Agencies: TVA, USDA, USGS, and USEPA** were prepared. Interpretation of the tables is left to the reader.

TABLE 1 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Water Quality Base Funding

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEARS:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
TENNESSEE VALLEY AUTHORITY (TVA)												
	$ WQ	2,136	1,717	2,171	2,469	3,175	5,863	6,223	6,316	5,800	6,265	8,961
a/ b/	$ TOTAL	162,475	137,063	129,162	129,162	132,900	125,000	99,528	100,000	103,000	103,000	87,596
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)												
	$ WQ	1,174,358	1,105,531	589,084	984,946	447,096	545,083	529,855	548,531	568,054	602,603	493,596
d/	$ TOTAL	21,280,303	25,067,104	28,086,611	24,554,178	25,486,923	27,343,900	25,681,309	27,180,843	32,613,150	35,038,670	34,431,588
UNITED STATES GEOLOGICAL SURVEY (USGS)												
	$ WQ	28,000	31,900	34,350	39,600	45,750	49,700	51,500	57,122	59,297	58,359	56,423
e/ f/	$ TOTAL	356,090	382,787	370,399	390,509	402,385	416,368	412,306	430,943	447,747	451,506	452,465
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)												
	$ WQ	343,110.5	350,099.9	253,553.6	227,371.0	239,855.6	263,130.1	258,002.4	288,529.6	285,550.7	311,546.8	134,457.1
g/	$ TOTAL	1,269,399.0	1,428,331.5	1,276,012.0	1,258,688.2	1,582,000.0	1,967,573.1	1,693,003.6	2,593,833.8	3,227,870.6	3,375,059.2	3,683,000.0
TOTAL:	**$ WQ**	1,547,604.5	1,489,247.9	879,158.6	1,254,386.0	735,876.6	863,776.1	845,580.4	900,498.6	918,701.7	978,773.8	693,437.1
	$ TOTAL	23,068,267.0	27,015,285.5	29,862,184.0	26,332,537.2	27,604,208.0	29,852,841.1	27,886,146.6	30,305,619.8	36,391,767.6	38,968,235.2	38,654,649.0

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a/ Tennessee Valley Authority $ TOTAL for 1980 and 1981 excludes appropriated funding for Northeast Alabama Coal-to-Methanol project.

b/ Tennessee Valley Authority $ TOTAL for 1983 excludes appropriated funding for the Jobs Bill Program.

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

d/ The sources of the USDA $ TOTALS are the USDA's Special Budgetary Tables, 1982–1990, Table 1; $ TOTALS are direct appropriations only (excluding permanent and trust fund appropriations).

e/ United States Geological Survey $ TOTALS for 1980, 1981, and 1982 reflect transfers for Minerals and Management Service for comparison purposes.

f/ United States Geological Survey $ TOTAL for 1987 reflects a transfer of $597,000 to the National Park Service.

g/ United States Environmental Protection Agency $ TOTALS were provided Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

TABLE 1 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Water Quality Base Funding
1980–1990

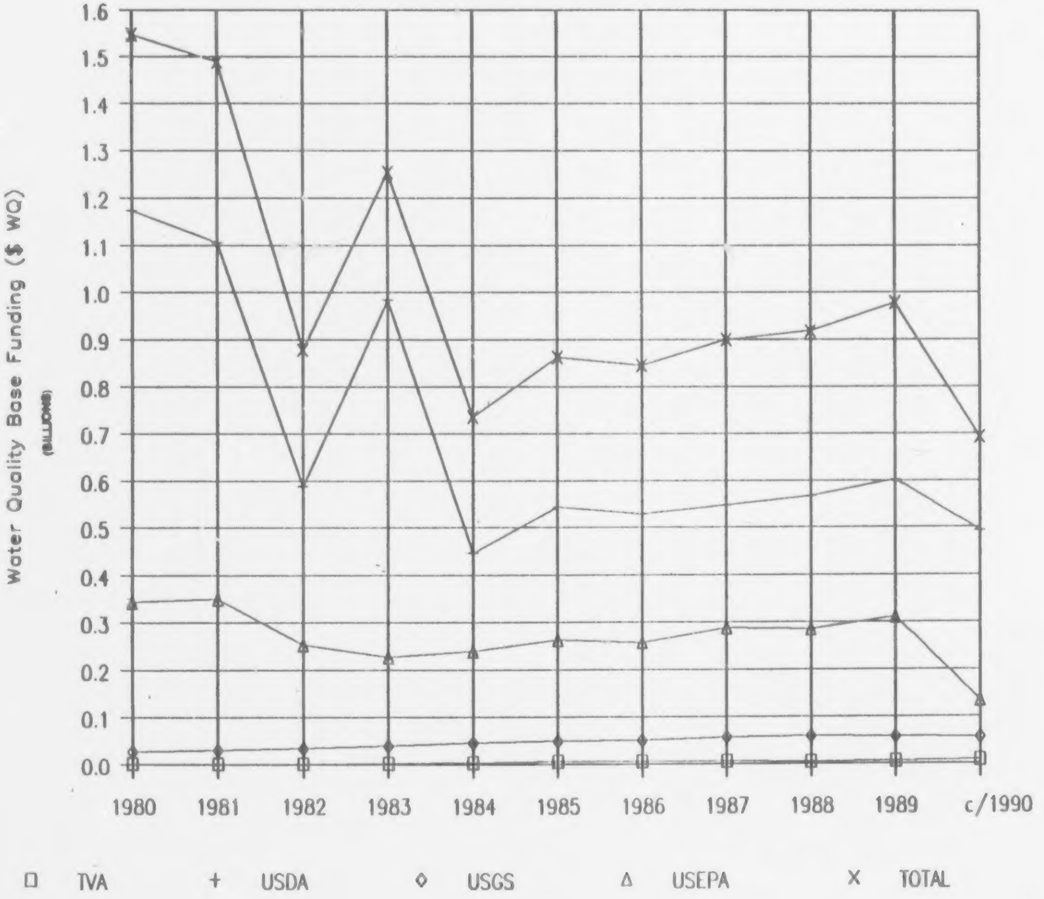

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TABLE 2 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Adjusted Water Quality Levels

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

	YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
	1982 GNP Deflator Index Values:	*0.855*	*0.934*	*1*	*1.04*	*1.086*	*1.123*	*1.146*	*1.185*	*1.237*	*1.286*	*1.332*
	TENNESSEE VALLEY AUTHORITY (TVA)											
	$ WQ	2,498.2	1,838.3	2,171.0	2,374.0	2,923.6	5,220.8	5,430.2	5,330.0	4,688.8	4,871.7	6,727.5
a/ b/	**$ TOTAL**	190,029.2	146,748.4	129,162.0	124,194.2	122,375.7	111,309.0	86,848.2	84,388.2	83,266.0	80,093.3	65,762.8
	UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)											
	$ WQ	1,373,518.1	1,183,652.0	589,084.0	947,063.5	411,690.6	485,381.1	462,351.7	462,895.4	459,219.1	468,587.1	370,567.6
d/	**$ TOTAL**	24,889,243.3	26,838,441.1	28,086,611.0	23,609,786.5	23,468,621.5	24,348,976.0	22,409,519.2	22,937,420.3	26,364,713.0	27,246,244.2	25,849,540.5
	UNITED STATES GEOLOGICAL SURVEY (USGS)											
	$ WQ	32,748.5	34,154.2	34,350.0	38,076.9	42,127.1	44,256.5	44,938.9	48,204.2	47,936.1	45,380.2	42,359.6
e/ f/	**$ TOTAL**	416,479.5	409,836.2	370,399.0	375,489.4	370,520.3	370,764.0	359,778.4	363,665.0	361,962.0	351,093.3	339,688.4
	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)											
	$ WQ	401,298.8	374,839.3	253,553.6	218,626.0	220,861.5	234,310.0	225,133.0	243,484.9	230,841.3	242,260.3	100,943.8
g/	**$ TOTAL**	1,484,677.2	1,529,262.8	1,276,012.0	1,210,277.1	1,456,721.9	1,752,068.7	1,477,315.5	2,188,889.3	2,609,434.6	2,624,462.8	2,765,015.0
TOTAL:	**$ WQ**	1,810,063.7	1,594,483.8	879,158.6	1,206,140.4	677,602.8	769,168.4	737,853.8	759,914.4	742,685.3	761,099.4	520,598.4
	$ TOTAL	26,980,429.2	28,924,288.5	29,862,184.0	25,319,747.3	25,418,239.4	26,583,117.6	24,333,461.3	25,574,362.7	29,419,375.6	30,301,893.6	29,020,006.8

a/ Tennessee Valley Authority $ TOTAL for 1980 and 1981 excludes appropriated funding for Northeast Alabama Coal–to–Methanol project.

b/ Tennessee Valley Authority $ TOTAL for 1983 excludes appropriated funding for the Jobs Bill Program.

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

d/ The sources of the USDA $ TOTALS are the USDA's Special Budgetary Tables, 1982–1990, Table 1; $ TOTALS are direct appropriations only (excluding permanent and trust fund appropriations).

e/ United States Geological Survey $ TOTALS for 1980, 1981, and 1982 reflect transfers for Minerals and Management Service for comparison purposes.

f/ United States Geological Survey $ TOTAL for 1987 reflects a transfer of $597,000 to the National Park Service.

g/ United States Environmental Protection Agency $ TOTALS were provided Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

TABLE 2 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Adjusted Water Quality Levels
1980–1990

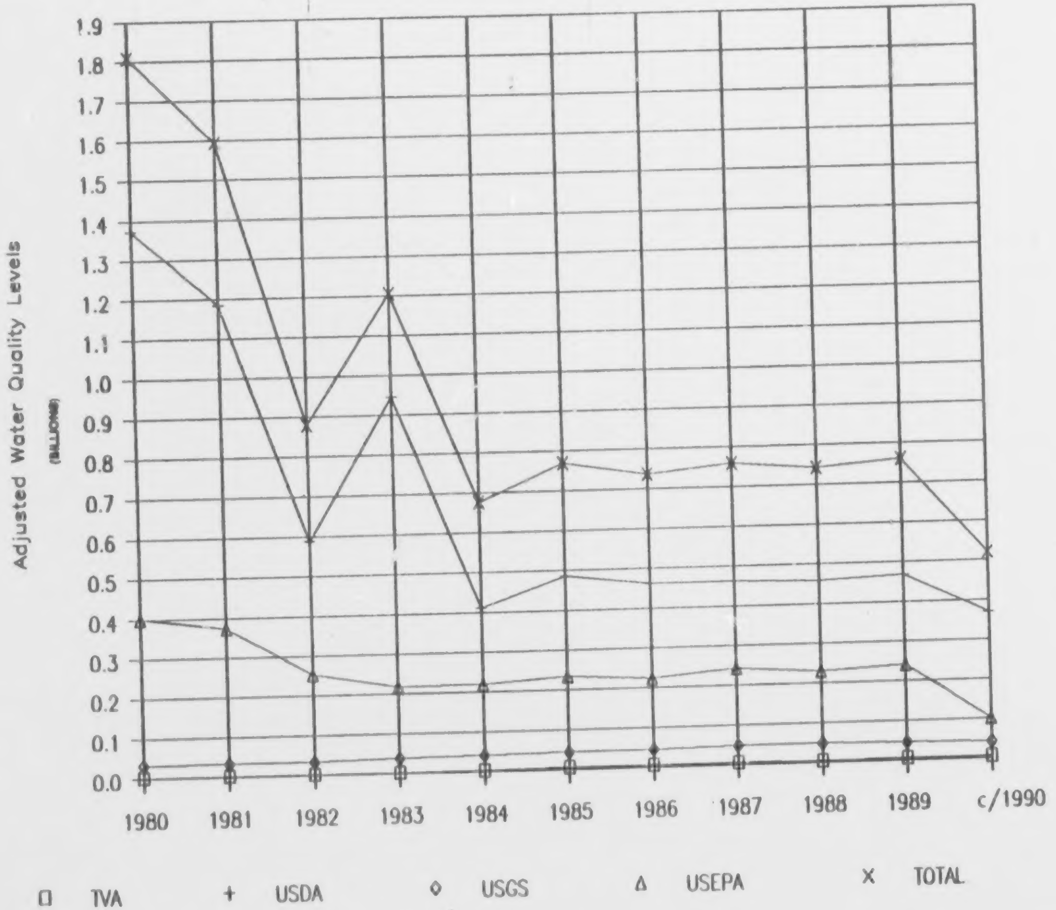

TABLE 3 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Water Quality Personnel Resources

1980–1990

WQ = Water Quality

FTE = Full-Time Equivalent

YEARS:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	TENNESSEE VALLEY AUTHORITY (TVA)											
h/	FTE WQ	44.1	28.5	35.5	33.4	42.4	78.2	85.2	75.5	65.5	73.9	113
h/	FTE TOTAL	3,610	3,050	2,900	2,900	2,750	2,630	2,500	2,250	1,980	1,950	1,850
	UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)											
	FTE WQ	839	760	1245	1347	1403	1519	1345	1548	1509	1520	1781
l/	FTE TOTAL	113,859	108,013	100,953	94,876	94,195	93,173	90,146	89,380	90,365	93,076	92,921
	UNITED STATES GEOLOGICAL SURVEY (USGS)											
i/	FTE WQ	487	548	920	981	1061	1078	1073	1128	1097	1113	1080
j/	FTE TOTAL	7,603	7,511	10,231	10,010	9,837	9,749	9,596	9,148	9,330	9,437	9,214
	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)											
	FTE WQ	3824.9	3471.2	3010.1	2438.7	2415.3	2420.5	2421.9	2481.4	2459.6	2444.7	689.2
k/	FTE TOTAL	13,587.0	13,130.0	12,161.0	11,025.0	11,597.8	12,625.8	11,644.7	13,661.7	14,448.8	14,720.0	15,130.3
TOTAL:	FTE WQ	5,195.0	4,807.7	5,210.6	4,800.1	4,921.7	5,095.7	4,925.1	5,232.9	5,131.1	5,151.6	3,663.2
	FTE TOTAL	138,659.0	131,704.0	126,245.0	118,811.0	118,379.8	118,177.8	113,886.7	114,439.7	116,123.8	119,183.0	119,115.3

h/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

i/ FTE's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982.
Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

j/ United States Geological Survey FY 1980 and FY 1981 figures are positions, not FTE's.

k/ United States Environmental Protection Agency FTE TOTALS were provided Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

l/ United States Department of Agriculture's FTE TOTALS were derived from the direct appropriation totals in the USDA Explanatory Notes to the Appropriations Committee. 1980–1988; and the USDA Special Budgetary Tables, 1990.

TABLE 3 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Water Quality Personnel Resources

1980-1990

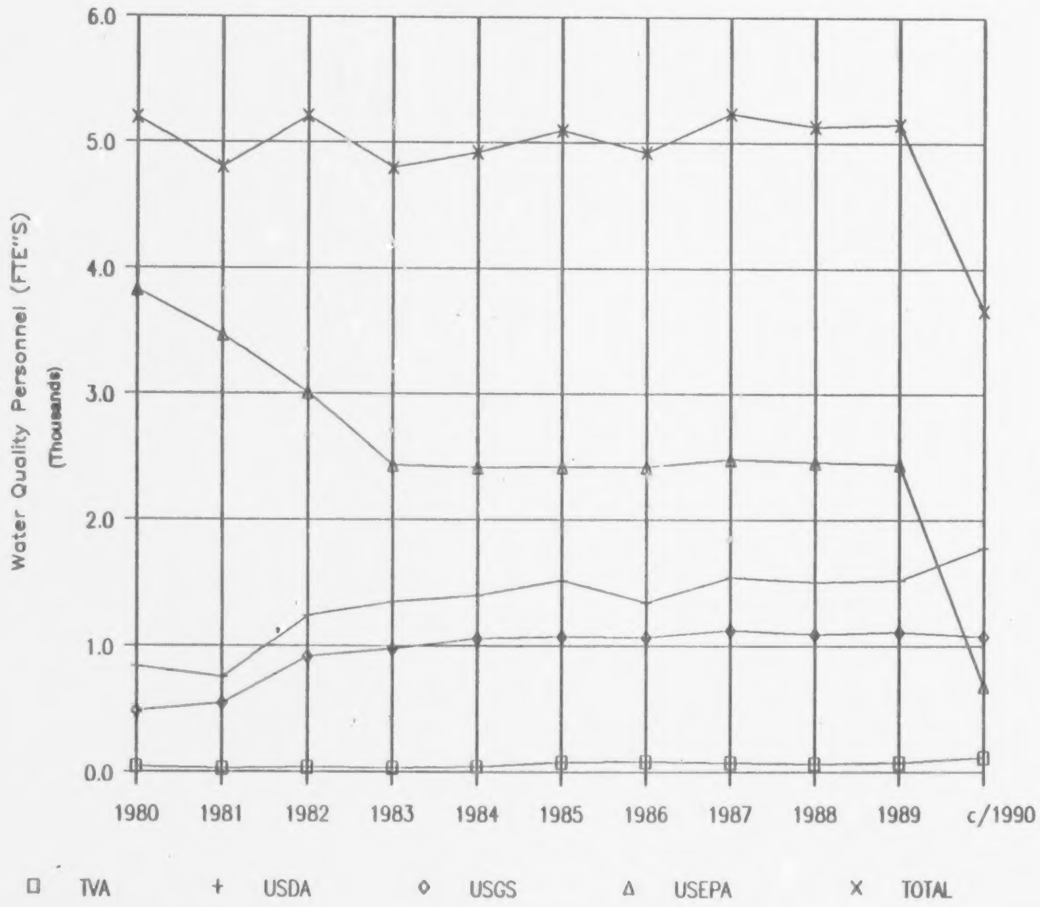

TABLE 4 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Percentage of Adjusted Funding Directed to Water Quality

1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

YEARS:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
TENNESSEE VALLEY AUTHORITY (TVA)												
	$ WQ	2,498.2	1,838.3	2,171.0	2,374.0	2,923.6	5,220.8	5,430.2	5,330.0	4,688.8	4,871.7	6,727.5
a/ b/	$ TOTAL	190,029.2	146,748.4	129,162.0	124,194.2	122,375.7	111,309.0	86,848.2	84,388.2	83,266.0	80,093.3	65,762.8
	$ WQ/$ TOTAL (%)	1.3	1.3	1.7	1.9	2.4	4.7	6.3	6.3	5.6	6.1	10.2
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)												
	$ WQ	1,373,518.1	1,183,852.0	589,084.0	947,063.5	411,690.6	485,381.1	462,351.7	462,895.4	459,219.1	468,587.1	370,567.6
d/	$ TOTAL	24,889,243.3	26,838,441.1	28,086,611.0	23,609,786.5	23,468,621.5	24,348,976.0	22,409,519.2	22,937,420.3	26,364,713.0	27,246,244.2	25,849,540.5
	$ WQ/$ TOTAL (%)	5.5	4.4	2.1	4.0	1.8	2.0	2.1	2.0	1.7	1.7	1.4
UNITED STATES GEOLOGICAL SURVEY (USGS)												
	$ WQ	32,748.5	34,154.2	34,350.0	38,076.9	42,127.1	44,256.5	44,938.9	48,204.2	47,936.1	45,380.2	42,359.6
e/ f/	$ TOTAL	416,479.5	409,836.2	370,399.0	*375,489.4*	370,520.3	370,764.0	359,778.4	363,665.0	361,962.0	351,093.3	339,688.4
	$ WQ/$ TOTAL (%)	7.9	8.3	9.3	10.1	11.4	11.9	12.5	13.3	13.2	12.9	12.5
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)												
	$ WQ	401,298.8	374,839.3	253,553.6	218,626.0	220,861.5	234,310.0	225,133.0	243,484.9	230,841.3	242,260.3	100,943.8
g/	$ TOTAL	1,484,677.2	1,529,262.8	1,276,012.0	1,210,277.1	1,456,721.9	1,752,068.7	1,477,315.5	2,188,889.3	2,609,434.6	2,624,462.8	2,765,015.0
	$ WQ/$ TOTAL (%)	27.0	24.5	19.9	18.1	15.2	13.4	15.2	11.1	8.8	9.2	3.7
TOTAL:	**$ WQ**	1,810,063.7	1,594,483.8	879,158.6	1,206,140.4	677,602.8	769,168.4	737,853.8	759,914.4	742,685.3	761,099.4	520,598.4
	$ TOTAL	26,980,429.2	28,924,288.5	29,862,184.0	25,319,747.3	25,418,239.4	26,583,117.6	24,333,461.3	25,574,362.7	29,419,375.6	30,301,893.6	29,020,006.8
	$ WQ/$ TOTAL (%)	6.7	5.5	2.9	4.8	2.7	2.9	3.0	3.0	2.5	2.5	1.8

a/ Tennessee Valley Authority $ TOTAL for 1980 and 1981 excludes appropriated funding for Northeast Alabama Coal-to-Methanol project.

b/ Tennessee Valley Authority $ TOTAL for 1983 excludes appropriated funding for the Jobs Bill Program.

c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.

d/ The sources of the USDA $ TOTALS are the USDA's Special Budgetary Tables, 1982–1990, Table 1; $ TOTALS are direct appropriations only (excluding permanent and trust fund appropriations).

e/ United States Geological Survey $ TOTALS for 1980, 1981, and 1982 reflect transfers for Minerals and Management Service for comparison purposes.

f/ United States Geological Survey $ TOTAL for 1987 reflects a transfer of $597,000 to the National Park Service.

g/ United States Environmental Protection Agency $ TOTALS were provided Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

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TABLE 4 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Percentage of Adjusted Funding Directed to Water Quality

1980–1990

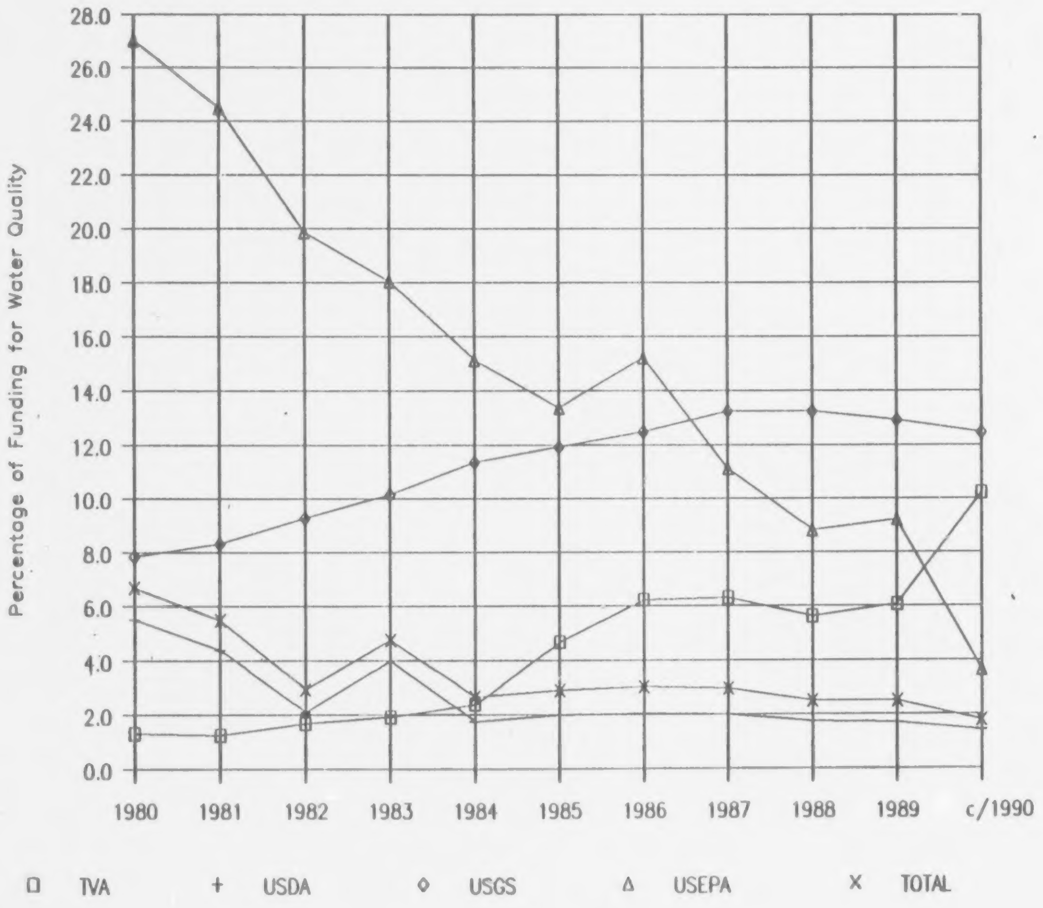

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TABLE 5 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Percentage of Total Personnel Assigned to Water Quality

1980–1990

WQ = Water Quality

FTE = Full–Time Equivalent

YEARS:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TENNESSEE VALLEY AUTHORITY (TVA)												
h/	FTE WQ	44.1	28.5	35.5	33.4	42.4	78.2	85.2	75.5	65.5	73.9	113
h/	FTE TOTAL	3,610	3,050	2,900	2,900	2,750	2,630	2,500	2,250	1,980	1,950	1,850
	FTE WQ/FTE TOTAL (%)	1.2	0.9	1.2	1.2	1.5	3.0	3.4	3.4	3.3	3.8	6.1
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)												
	FTE WQ	839	760	1245	1347	1403	1519	1345	1548	1509	1520	1781
l/	FTE TOTAL	113,859	108,013	100,953	94,876	94,195	93,173	90,146	89,380	90,365	93,076	92,921
	FTE WQ/FTE TOTAL (%)	0.7	0.7	1.2	1.4	1.5	1.6	1.5	1.7	1.7	1.6	1.9
UNITED STATES GEOLOGICAL SURVEY (USGS)												
i/	FTE WQ	487	548	920	981	1061	1078	1073	1128	1097	1113	1080
j/	FTE TOTAL	7,603	7,511	10,231	10,010	9,837	9,749	9,596	9,148	9,330	9,437	9,214
	FTE WQ/FTE TOTAL (%)	6.4	7.3	9.0	9.8	10.8	11.1	11.2	12.3	11.8	11.8	11.7
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)												
	FTE WQ	3824.9	3471.2	3010.1	2438.7	2415.3	2420.5	2421.9	2481.4	2459.6	2444.7	689.2
k/	FTE TOTAL	13,587.0	13,130.0	12,161.0	11,025.0	11,597.8	12,625.8	11,644.7	13,661.7	14,448.8	14,720.0	15,130.3
	FTE WQ/FTE TOTAL (%)	28.2	26.4	24.8	22.1	20.8	19.2	20.8	18.2	17.0	16.6	4.6
TOTAL:	**FTE WQ**	5,195.0	4,807.7	5,210.6	4,800.1	4,921.7	5,095.7	4,925.1	5,232.9	5,131.1	5,151.6	3,663.2
	FTE TOTAL	138,659.0	131,704.0	126,245.0	118,811.0	118,379.8	118,177.8	113,886.7	114,439.7	116,123.8	119,183.0	119,115.3
	FTE WQ/FTE TOTAL (%)	3.7	3.7	4.1	4.0	4.2	4.3	4.3	4.6	4.4	4.3	3.1

h/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

i/ FTE's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982. Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

j/ United States Geological Survey FY 1980 and FY 1981 figures are positions, not FTE's.

k/ United States Environmental Protection Agency FTE TOTALS were provided Mr. Rick Peterson, Chief of the Budget Control Section, Office of the Controller, EPA.

l/ United States Department of Agriculture's FTE TOTALS were derived from the direct appropriation totals in the USDA Explanatory Notes to the Appropriations Committee, 1980–1988; and the USDA Special Budgetary Tables, 1990.

TABLE 5 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Percentage of Total Personnel Assigned to Water Quality
1980–1990

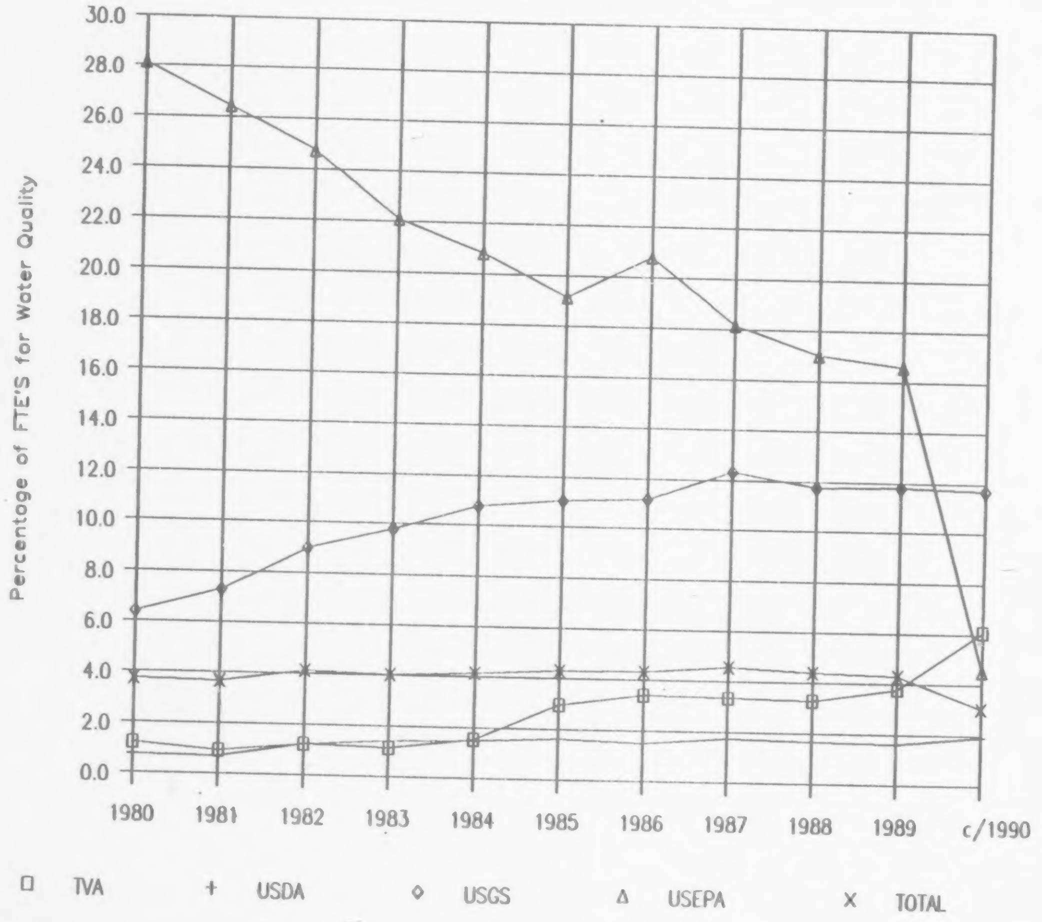

TABLE 6 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality
1980–1990

(Thousands of Dollars)

WQ = Water Quality

$ = Appropriated Funds

FTE = Full-Time Equivalent

YEARS:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	c/1990
TENNESSEE VALLEY AUTHORITY (TVA)												
	$ WQ	2,498.2	1,838.3	2,171.0	2,374.0	2,923.6	5,220.8	5,430.2	5,330.0	4,688.8	4,871.7	6,727.5
h/	FTE WQ	44.1	28.5	35.5	33.4	42.4	78.2	65.2	75.5	65.5	73.9	113
	$ WQ/FTE WQ	56.6	64.5	61.2	71.1	69.0	66.8	63.7	70.6	71.6	65.9	59.5
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)												
	$ WQ	1,373,518.1	1,183,652.0	589,084.0	947,063.5	411,690.6	485,381.1	462,351.7	462,895.4	459,219.1	468,587.1	370,567.6
	FTE WQ	839	760	1245	1347	1403	1519	1345	1548	1509	1520	1781
	$ WQ/FTE WQ	1637.1	1557.4	473.2	703.1	293.4	319.5	343.8	299.0	304.3	308.3	208.1
UNITED STATES GEOLOGICAL SURVEY (USGS)												
	$ WQ	32,748.5	34,154.2	34,350.0	38,076.9	42,127.1	44,256.5	44,936.9	48,204.2	47,936.1	45,380.2	42,359.6
i/	FTE WQ	487	548	920	981	1061	1078	1073	1128	1097	1113	1080
	$ WQ/FTE WQ	67.2	62.3	37.3	38.8	39.7	41.1	41.9	42.7	43.7	40.8	39.2
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)												
	$ WQ	401,298.8	374,839.3	253,553.6	218,626.0	220,861.5	234,310.0	225,133.0	243,484.9	230,841.3	242,260.3	100,943.8
	FTE WQ	3824.9	3471.2	3010.1	2438.7	2415.3	2420.5	2421.9	2481.4	2459.6	2444.7	689.2
	$ WQ/FTE WQ	104.9	108.0	84.2	89.6	91.4	96.8	93.0	98.1	93.9	99.1	146.5
TOTAL:	**$ WQ**	1,810,063.7	1,594,483.8	879,158.6	1,206,140.4	677,602.8	769,168.4	737,853.8	759,914.4	742,685.3	761,099.4	520,598.4
	FTE WQ	5,195.0	4,807.7	5,210.6	4,800.1	4,921.7	5,095.7	4,925.1	5,232.9	5,131.1	5,151.6	3,663.2
	$ WQ/FTE WQ	348.4	331.7	168.7	251.3	137.7	150.9	149.8	145.2	144.7	147.7	142.1

h/ All personnel levels are estimates. Source: TVA, Budget and Financial Services, Resource Development, and Business Operations.

i/ FTE's represent direct appropriated funds. FTE TOTALS for FY 1980 and FY 1981 are only approximations; FTE values were not in use prior to 1982. Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.

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TABLE 6 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Relationship of Adjusted Water Quality Funding to Personnel Assigned to Water Quality

1980–1990

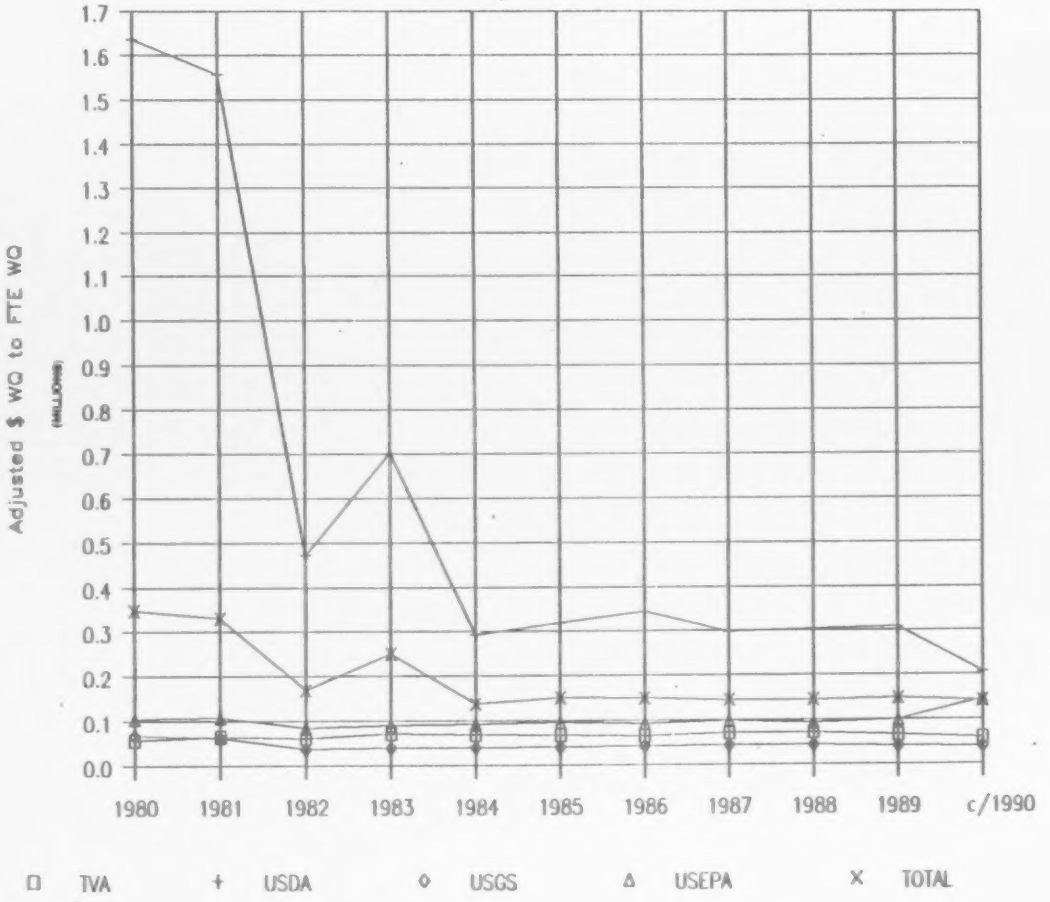

TABLE 7 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Relationship of Adjusted Total Funding to Total Personnel
1980–1990

(Thousands of Dollars)

WQ = Water Quality $ = Appropriated Funds FTE = Full-Time Equivalent

YEARS:		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TENNESSEE VALLEY AUTHORITY (TVA)												
a/ b/	$ TOTAL	190,029.2	146,748.4	129,162.0	124,194.2	122,375.7	111,309.0	86,848.2	84,388.2	83,266.0	80,093.3	65,762.8
h/	FTE TOTAL	3,610	3,050	2,900	2,900	2,750	2,630	2,500	2,250	1,980	1,950	1,850
	$ TOTAL/FTE TOTAL	52.6	48.1	44.5	42.8	44.5	42.3	34.7	37.5	42.1	41.1	35.5
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA)												
d/	$ TOTAL	24,889,243.3	26,838,441.1	28,086,611.0	23,609,786.5	23,468,621.5	24,348,976.0	22,409,519.2	22,937,420.3	26,364,713.0	27,246,244.2	25,849,540.5
l/	FTE TOTAL	113,859	108,013	100,953	94,876	94,195	93,173	90,146	89,380	90,365	93,076	92,921
	$ TOTAL/FTE TOTAL	218.6	248.5	278.2	248.8	249.1	261.3	248.6	256.6	291.8	292.7	278.2
UNITED STATES GEOLOGICAL SURVEY (USGS)												
e/ f/	$ TOTAL	416,479.5	409,836.2	370,399.0	375,489.4	370,520.3	370,764.0	359,778.4	363,665.0	361,962.0	351,093.3	339,688.4
j/	FTE TOTAL	7,603	7,511	10,231	10,010	9,837	9,749	9,596	9,148	9,330	9,437	9,214
	$ TOTAL/FTE TOTAL	54.8	54.6	36.2	37.5	37.7	38.0	37.5	39.8	38.8	37.2	36.9
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA)												
g/	$ TOTAL	1,484,677.2	1,529,262.8	1,276,012.0	1,210,277.1	1,456,721.9	1,752,068.7	1,477,315.5	2,188,889.3	2,609,434.6	2,624,462.8	2,765,015.0
k/	FTE TOTAL	13,587.0	13,130.0	12,161.0	11,025.0	11,597.8	12,625.8	11,644.7	13,661.7	14,4[illegible]	14,720.0	15,130.3
	$ TOTAL/FTE TOTAL	109.3	116.5	104.9	109.8	125.6	138.8	126.9	160.2	150.6	178.3	182.7
TOTAL:	**$ TOTAL**	**26,980,429.2**	**28,924,288.5**	**29,862,184.0**	**25,319,747.3**	**25,418,239.4**	**26,583,117.6**	**24,333,461.3**	**25,574,362.7**	**29,419,375.6**	**30,301,893.6**	**29,020,006.8**
	FTE TOTAL	**138,659.0**	**131,704.0**	**126,245.0**	**118,811.0**	**118,379.8**	**118,177.8**	**113,886.7**	**114,439.7**	**116,123.8**	**119,183.0**	**119,115.3**
	$ TOTAL/FTE TOTAL	**194.6**	**219.6**	**236.5**	**213.1**	**214.7**	**224.9**	**213.7**	**223.5**	**253.3**	**254.2**	**243.6**

a/ Tennessee Valley Authority $ TOTAL for 1980 and 1981 excludes appropriated funding for Northeast Alabama Coal-to-Methanol project.
b/ Tennessee Valley Authority $ TOTAL for 1983 excludes appropriated funding for the Jobs Bill Program.
c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.
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Source: Mrs. Susan L. Collier, Budget Analyst, Office of Assistant Director for Programs, USGS.
j/ United States Geological Survey FY 1980 and FY 1981 figures are positions, not FTE's.
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TABLE 7 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Relationship of Adjusted Total Funding to Total Personnel

1980–1990

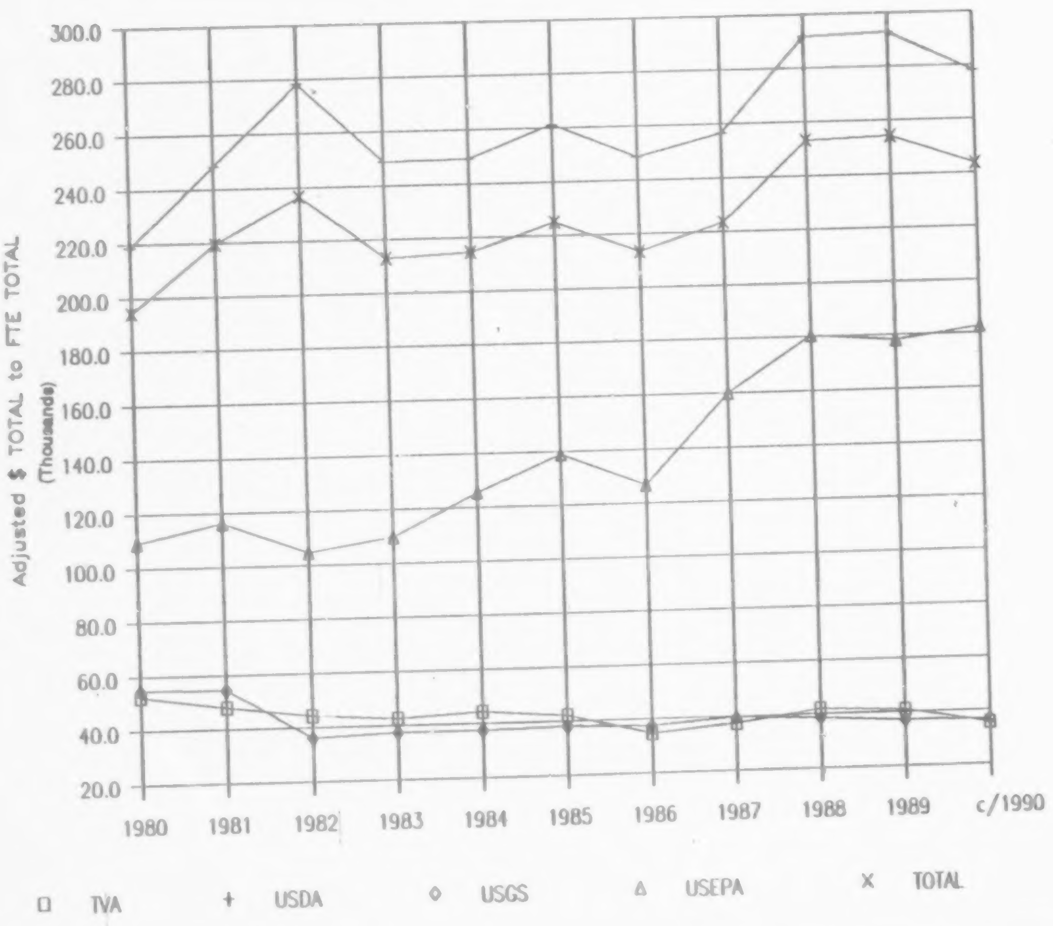

TABLE 8 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person
1980–1990

WQ = Water Quality

$ = Appropriated Funds

FTE = Full-Time Equivalent

YEARS:	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
TENNESSEE VALLEY AUTHORITY (TVA) $ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.1	1.3	1.4	1.7	1.5	1.6	1.8	1.9	1.7	1.6	1.7
UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) $ WQ/FTE WQ $ TOTAL/FTE TOTAL	7.5	6.3	1.7	2.8	1.2	1.2	1.4	1.2	1.0	1.1	0.7
UNITED STATES GEOLOGICAL SURVEY (USGS) $ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.2	1.1	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA) $ WQ/FTE WQ $ TOTAL/FTE TOTAL	1.0	0.9	0.8	0.8	0.7	0.7	0.7	0.6	0.5	0.6	0.8
TOTAL: $ WQ/FTE WQ	1.8	1.5	0.7	1.2	0.6	0.7	0.7	0.6	0.6	0.6	0.6
$ TOTAL/FTE TOTAL											

a/ Tennessee Valley Authority $ TOTAL for 1980 and 1981 excludes appropriated funding for Northeast Alabama Coal-to-Methanol project.
b/ Tennessee Valley Authority $ TOTAL for 1983 excludes appropriated funding for the Jobs Bill Program.
c/ Water Quality and Total Funding levels are derived from the President's FY 1990 Budget Request.
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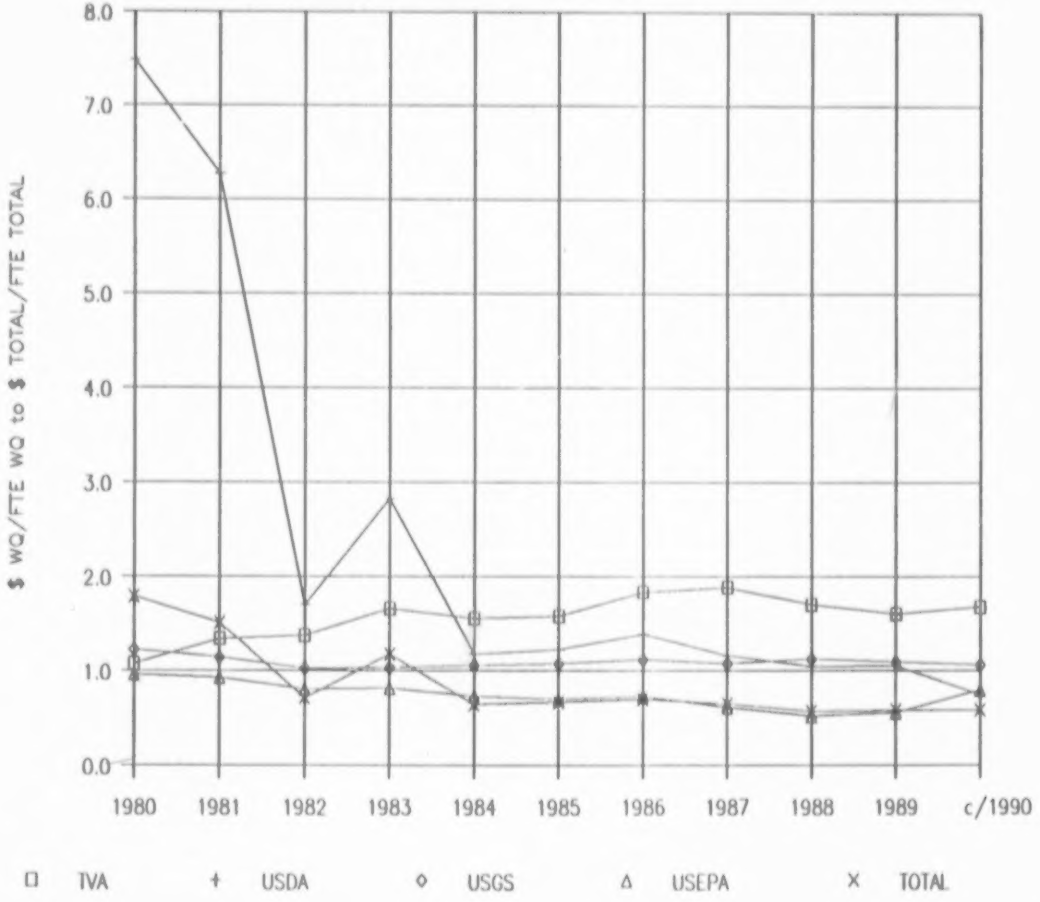
TABLE 8 OF 8:

UNITED STATES FEDERAL AGENCIES: TVA, USDA, USGS, AND USEPA

Adjusted Funding per Person Assigned to Water Quality Relative to Adjusted Total Funding per Person
1980–1990



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